A PRACTICAL TREATISE ON AUSCULTATION.

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AND

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C'est l'entendement qui veoid et qui oyt.—Montaigne.

TRANSLATED WITH NOTES,

BY

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WITH

AN APPENDIX,

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AUTHOR'S PREFACE.

Scarcely had the genius of Laennec given birth to auscultation, when it was received, by all who are interested in the progress of medicine, as one of the most valuable discoveries. The signal services which it renders to the science of diagnosis, no one will question, who will take the trouble to make himself acquainted with the new method of investigation, the immense importance of which could not fail to engage, from the very first, the attention of every unprejudiced mind. The emulation which it has excited, the efforts which have consequently been made, either to render its results more precise, or to extend its sway, are proofs of its importance; and the extensive use which has been derived from it, the happy application which has been made of it, to a more minute, and complete examination of the diseases of the circulatory apparatus, to the obstetric art, and to surgery, bear testimony to the powerful impulse, which it has given to the science of medicine.

If, in the midst of this general enthusiasm, some incredulous persons have not been able to appreciate the value of auscultation, it must be attributed to the indolence of their minds, which has prevented them from perceiving the truth; nor are we disposed to give them credit for the sincerity of their scepticism.

In these days, any physician, who is at all worthy of the name, cannot shut his ear to the information which the stethoscope reveals, nor dispute the importance of Laennec's invention.

But if the merit of this admirable discovery should not appear sufficiently evident in itself, we could find a brilliant demonstration of its value, in the incessant concourse of the most distinguished young physicians of all countries at our universities, and in the eagerness with which they seek to be instructed in the truths of auscultation.

Enlightened by the meditation on the magnificent work of Laennec, thoroughly imbued with the doctrines of the illustrious masters of the schools of Paris, we have for a long time devoted ourselves with ardor to a profound study of auscultation, and we have endeavored, as far as possible, to propagate the knowledge of its doctrines. After having for several years expounded in our *oral lectures* the principles of stethoscopy; after having taught its application at the sick bed, we have thought that a *work* might facilitate the study of it, and render it more popular. It appeared to us useful to combine in our treatise the precepts of Laennec, and the facts he has produced, with the new dis-

coveries resulting from the labors of the observers here and abroad; and to construct from these scattered elements, a system which might be a complete representation of the signs of auscultation as it is at present.

This task might have been easy for him, who has no other ambition, than to recapitulate the labors of others, without critical remarks and improvements, and who desires merely to make a compendium, where the original author is more or less mutilated.

But, devoted as we have been for a long time to the observation of clinical facts, we have considered a mere compilation unworthy of our care, and have understood in another sense, a treatise on auscultation.

In order to compose a really useful work, and to render it as complete as it is in our power, it becomes incumbent upon us to embody those discoveries of Laennec, which have been confirmed by the most minute observations, to appreciate the value of the amendments, which the experience of others have suggested, to judge of the importance of new conquests, by which auscultation has been enriched, and to endeavor, on our part, to contribute to its progress. It has been our effort to accomplish this, by an exact and strict analysis of all stethoscopic facts, viewed in the various apparatus of the animal economy, and by the examination of works published on that subject in France, Germany, and England. The remarks we have embodied in several chapters, and, in particular, in that which treats of stethoscopy as applied to diseases of the heart, and to affections of the heart, and to affections of the larynx, will give proof, that we have likewise contributed our share to the construction of the common edifice.

The form of the work has received our full attention; if, on the one hand, we have made it a point to present, in a strictly logical order, the numerous facts connected with the study of auscultation, and to classify, methodically, the physical signs, of which the physician receives intelligence through the medium of the ear, we have, on the other hand. carefully aimed at perspicuity and precision of language. Convinced that there exists *shades* of acoustic sensations, as there are of color, and that it is impossible to find words to convey an adequate idea of them, we have rather refrained from increasing the stethoscopic nomenclature; we have been sparing in the use of new terms and infinite subdivisions, lest the fundamental principles might be lost sight of in the midst of too elaborate and minute details, and lest the saying of an ancient philosopher, regarding the writings of one of his fraternity, "*that they required a good swimmer for their reader*," might also be applied to our Treatise.

In the examination of the physical signs, we have generally adopted the following method: After having established the

rules, the practice of which is of importance for the exact perception of the sensations, we proceed to the description of the phenomena, absolutely considered; and we review them alternately in the physiological and pathological state; afterwards we examine a particular morbid phenomenon, successively as regards its synonymes, its characters, its differential diagnosis, its mechanism, its signification, and, finally, its semeiological value.

It is evident, that this methodical arrangement, the divisions of which we have rigorously preserved, comprises all considerations relating to the complete and profound appreciation of the stethoscopic phenomena. We have examined each sign, as is done in semeiology, in regard to the different morbid symptoms, pain, dyspnœa, vomiting, &c., and we have particularly insisted on a semeiological inquiry, properly so called. After having, for example, traced the characters of a râle, we have determined its pathological signification, and pointed out, not only the diseases, where it occurs (an indication, to which the authors of treatises on auscultation have generally confined themselves), but also the more or less frequent occurrence of ronchus, its special forms in these different affections, and its favorite seat at one or other point of the thorax, according to the more or less frequent occurrence of the diseases, the nature of the anatomical alterations, and according to their most general situation at the various regions of the chest.

Accordingly, in the greater number of cases, we have been enabled to determine the diagnostic value of the signs disclosed by the stethoscope, whether it be, on the one hand, the absolute value of the acoustic fact, independent of any accessory circumstance, or on the other hand, its relative value, *i. e.* the semeiological importance of the phenomenon, confronted with the greater or lesser number of concomitant circumstances. By means of the abstract theory of the physical signs, as perceived by the ear, and by means of the simultaneous and comparative examination of other sensible or deducible phenomena, we have thus succeeded in establishing certain *laws of auscultation*, based occasionally on statistical data, but more frequently on the knowledge of the laws of pathology or morbid anatomy, formulas easy to recollect, and the application of which, appears to us to contribute greatly to the rapid and sure construction of our diagnosis.

The enumeration and discussion of the various points of acoustic semeiology, the difficulty, and at the same time, the magnitude of several other practical questions relating to physiology or pathology, and the explanation of some researches of our own, obliged us to go into somewhat lengthened details.

We trust we shall not be accused of prolixity, considering that we have pursued the study of auscultation throughout the whole economy, and that without treating in separate chapters on the

other physical methods, on *percussion, inspection, &c.* we merely speak of them incidentally when discussing the value of the stethoscopic signs. We shall believe, on the contrary, that we have been brief, if we have succeeded in producing a work, which may not be unworthy of the illustrious pathologists, by whose lessons and writings we have been benefited.

Moreover, in order to simplify the labor for beginners, and to render the principal facts embodied in this treatise more conspicuous and intelligible, we have, at the end of the work, given a short *Recapitulation* of the stethoscopic signs. We advise the novice in stethoscopy to proceed from the simple to the compound, and at first to confine himself to the summary, until afterwards, when his senses are more experienced, and his medical knowledge more extensive, when he should have recourse to the details, either with the view of clearing up doubtful points, or of rendering his previous notions more complete.

In order to explain the mechanism of the production of sonorous phenomena, we have been obliged to touch upon physical questions, but we have done so with the greatest reserve. We attach, besides, a very secondary importance to these explanations; we do not pretend to know more of these difficult problems, than the celebrated Academicians whom we have consulted, and who have in general replied to our interrogations by avowing their ignorance, or, more properly speaking, who have arrested us on the limits of actual science.

Having had it in our power to make our selection of various explanations advanced by different authors, we have preferred founding our opinions on the results of experiments, and when these experimental *data* became defective, we have decided in favor of the most rational hypothesis, which accorded best with the *material* disposition of the media where the phenomenon occurs, and which is supported by pathological principles.

We have studied the facts without prejudice, without pre-disposition in favor of system, and without respect of persons; we have given a faithful description of these; and, when we have combated opinions at variance with our own, we trust we have done so with that guardedness of expression, which is due to scientific discussions. At all events, we have had but one object in view—utility; and but one motive—the love of truth. We have also preserved our freedom of thought, convinced of the truth of our opinions, but, at the same time, being ready to modify them, if farther research on our own part, or on the part of others, should convince us of error.

Is not a change in such a case, a change for improvement? And it is improvement which forms the ultimate object of all our exertions.

BARTH. HENRY ROGERS.

TREATISE

ON

AUSCULTATION.

INTRODUCTION.

In surveying the progress of medicine, we are struck with two principal considerations, viz: the influence of pathological anatomy, and the equally powerful influence of the discovery and improvement of the physical methods of diagnosis. What a gap there existed in pathology as long as the attention of physicians was limited merely to functional symptoms! How much more precise, on the other hand, are the descriptions found in ancient authors, of diseases whose morbid characters could be appreciated by the eye? This single example proves, how much more easily the sensible phenomena are discovered or apprehended, and how much better they are recollected, than those which address themselves only to the mind, and shews the immense advantages which thereby arise to diagnosis. The manifestation of these physical phenomena is independent of the caprice or ignorance of the patient: he carries them about him, without being able to simulate or to conceal, to exaggerate or to lessen them. The disease is thus exhibited in its proper aspect, and the judgment of the physician is just and precise, in proportion as the phenomena are numerous and well developed.

Let us now trace the progress of semeiology through its different epochs. At first, we observe the symptoms transformed into entities; single denominations, such as *vomiting*, *pain*, *fever*, &c., employed to express opposite conditions, by one and the same type; complicated groups, composed of ambiguous and heterogeneous elements, where the apparent order and simplicity are, in fact, total confusion and disorder.

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Semeiology gains afterwards in power and influence, the more clearly observers begin to see, the better they learn to make use of their senses, and to improve their capacity, and the more the physical methods of exploration, assisted by induction and reasoning, are developed: the first formed were the pathological classes, then followed the genera, next the species, and at last harmony and unity sprung from this immense labor of judicious analysis.

Percussion, even before it was raised to that state of perfection, which it owes to M. Piorry, had already, in a great measure, contributed to this happy result. But what an immense territory remained to be explored, after the valuable discovery of auscultation had been made,—that discovery, which the medical art has welcomed with gratitude, and which will raise its author to a higher rank than Avenbrugger, and place him on the same level with Hippocrates! How invaluable are the services which it has rendered to the most useful of sciences; how much has it contributed at once to the knowledge of diseases, and, consequently, to the proper method of their treatment!

HISTORY.

Laennec has not concealed from his contemporaries, that some traces of auscultation are found in the works of Hippocrates: he has quoted a passage, where the father of medicine has incontestibly alluded to the use of the application of this method: *if you listen by applying the ear to the chest.* But this passage, neglected by his commentators, had completely fallen into oblivion, and the precious thread, which might have led to the most beautiful discovery, was lost, and only found again by chance after twenty-two centuries. A paragraph in Harvey's Dissertation (de Motu Cordis, etc., tactus 79), proves that the *sounds* of the heart had not escaped him, who discovered the circulation; "when," says he, "by the motions of the organ a portion of the blood passes from the veins into the arteries, *pulsum fieri et exaudiri in pectore contingit;*" he even compares this sound to that heard in a horse during the act of deglutition: *sonitum facit, et pulsum quemdam et auscultantibus et tangentibus exhibet.* But this remark, which is exclusively physiological, does not prove, that Harvey, or any other physician of his time, has derived advantage from auscultation for the investigation of the diseases of the heart.

The very fact, to which he adverts, was not generally known, since Æmilius Parisanus, a physician of Venice, in his refutation of Harvey's ideas, absolutely denies the existence of this sound, *quem nos surdastri audire non possumus*, and he adds ironically: It is heard no where, but at London, *tantummodo Londini exauditur*. (Recentiorum Disceptationes de Motu Cordis, Sanguinis et Chyli in Animalibus, Lugduni Batavorum, 1647. P. 101 and 107).

It appears that Corvisart employed immediate auscultation before the invention of the stethoscope, since, in his *Essay on the Diseases of the Heart*, he speaks of having frequently heard pulsations on applying the ear to the chest, (Corvisart, 3d ed. p. 396). Boyle, fellow-student of Laennec, employed likewise this method, of which he had probably a traditionary knowledge, as pupil of the clinical professor at La Charité: but Corvisart, Boyle, and Laennec himself, at this period, derived no other instruction from it, than that of hearing the pulsations of the heart more forcibly in cases, where it is not easily distinguished by the mere application of the hand. Those vague and imperfect notions which have since been revived, and of which Laennec was ignorant, detract nothing from the merit of the discoverer, and no one has seriously thought of contesting it with him. These germs of auscultation would have remained unproductive, had they not been rendered fruitful by his genius. Nevertheless, it is curious to see, even in the case of Laennec, how the secrets of nature are more frequently betrayed by accidental circumstances, than elicited by scientific labors.

There is undoubtedly something *fortuitous* in the invention of the stethoscope, but it is one of those chances with which men of genius only meet, and which they alone can exalt to the dignity of the loftiest conceptions. The perfection to which Laennec has carried his discovery, claims our most profound admiration; for he has understood how to reap from its resources a plentiful harvest in this new field of observation, leaving his successors but little to glean; we have likewise to rejoice in the revolution, he has caused in the diagnosis of diseases of the chest, and in the impulse he has given to science by the aid of this vast lever. Notwithstanding the accumulated labors of observers of all ages,—notwithstanding the exertions of Avenbrugger,—the diagnosis of the affections of the chest, which are so common, that they carry off more than one third of mankind,* had remained in a state of uncer-

*Vide Appendix. Note A.

tainty and doubt, when suddenly a radiant light chased away the darkness, and Laennec, the inventor of Stethoscopy, replied, with a shout of triumph, to the mournful exclamation of Baglivi: "*O quantum difficile est curare morbos pulmonum! O quanto difficilius eosdem cognoscere!*"

Numerous disciples have followed the footsteps of Laennec: but the ear of the master had been so exact in its perception, that but a few stethoscopic signs remained to be discovered; a few, however, have been discovered. The observers of our days have, moreover, procured by their efforts a no less important result: they have contributed to a better methodical arrangement of the acoustic facts, and, above all, more rigorously determined their morbid signification; the relative or absolute value of the abnormal sound has been appreciated more precisely; in a word, criticism has completely the newly invented science. The names of those, who have added to the discoveries, or advanced the progress of auscultation, will be better introduced in the following chapters, when we shall give a particular description of each phenomena.

IMPORTANCE OF AUSCULTATION.

It would be useless to attempt to draw a parallel between auscultation and the other physical methods of exploration; its superiority will be rendered much more evident by the simple exhibition of the stethoscopic facts themselves. Suffice it briefly to set forth its advantages under the form of propositions.

1st. Auscultation reveals to us, whether the derangements in the respiratory act are symptomatic of a disease in the chest, or sympathetic of another affection, more or less remote. 2d. It discloses the alterations of the organs of the thorax even in the absence of any functional disorder.—3d. It not only proves the existence of a disease, but specifies also its seat, degree, extent, progress, complications, and sometimes its character. 4th. It often accomplishes the diagnosis with wonderful rapidity, and with almost mathematical rigour and certainty. 5th. It signalises diseases, which otherwise would have completely escaped the observer: in the speechless infant, which cannot yet *reflect on* its pain; in complicated cases, where the affection of several organs disguise one another; where the patient is delirious or *comatose;* in a word, whenever the physician is in want of information,

auscultation adds eminently to the value of the signs, which are appreciable by our senses. 6th. It bestows on our prognosis a precision and certainty, which are sometimes equal to those of diagnosis. 7th. Finally, it establishes a rational basis for therapeutics, and provides it with the most positive facts, as well as the most useful indications.

But this is not all: Auscultation does not only render direct services, by yielding a more exact knowledge of the disease, of its progress, its probable issue, and of its treatment; but it often assists semeiology in an *indirect*, but no less efficacious manner, and may, by the aid of the phenomena derived from the examination of the chest, disclose the nature of certain affections of the encephalic or abdominal organs. In order to illustrate this proposition, let us advert to some particular facts: an individual feels, at intervals, pains in the abdomen, and suffers from vomiting; the abdomen is increased in volume; there exists by constipation dulness on percussion towards the depending parts. What affection do those symptoms indicate? Is it chronic peritonitis? Is this peritonitis simple, or complicated with some other more severe disease? Now! if auscultation reveal, in this individual, signs of pulmonary tubercles, will not the diagnosis of the abdominal disease be considerably elucidated, and is it not very probable, that the peritonitis is *tubercular?* Another patient labors for several days under fever and diarrhœa, with slight colicky pains; although these phenomena seem to refer exclusively to an intestinal affection, yet, if we examine the chest, we hear a sonorous râle on both sides, and should rather suspect a species of typhus fever at its commencement, for pulmonary catarrh is very rarely complicated with *simple* enteritis, and very commonly with *follicular* enteritis. In conclusion, suppose that a child complains first of headache, that this is followed by fever and vomiting, and that the pain of the head is accompanied by delirium and convulsions; *if* the stethoscope reveal signs of tubercles in the lungs, is this not enough to prove the existence of *tubercular* meningitis?

Let us, however, beware of overvaluing auscultation, to the prejudice of other modes of exploration, and of despising the services, which these latter may render us. The stethoscope is in many cases deficient, for, on the one hand, the disposition of the material diseases, hinders the production or the perception of the physical phenomena; on the other hand, their complicated state manifests itself by multifarious sounds; and lastly, the different râles do not exhibit sufficiently

distinct characters. Auscultation stands then in need of assistance and control from other methods, especially from percussion. All the senses, guided and corrected by reason, ought to concur in the solution of this difficult problem, called disease: without this indispensable control of sensations by intelligence, disagnosis rests but on a doubtful basis. Auscultation is, however, not responsible for the errors of those, who rely on it too exclusively, or of those, who make bad use of its data. Some routine practitioners have found fault with it, as being more hurtful than useful to therapeutics, by paralysing the activity of the physician, who, after having rigorously *confirmed* the existence of organic alterations, and those frequently incurable, confines himself to the first part of his task. But are we to accuse science, when the person, whose duty it is to apply its results to medical treatment, stops half-way and leaves his work incomplete? Pathological anatomy had already been subjected to a similar reproach, but it is equally unjust to both. Auscultation, when properly understood, should enlighten the practitioner and not discourage him; the more precise the ideas are which he derives from it, the more will they enable him to oppose to disease the most appropriate medicaments, and so far as regards the expectations it may occasionally hold out to him, they should never degenerate *into a meditation on death.*

GENERAL RULES.

In auscultation there are certain general rules to be observed, in order to obtain such results, as will be at the same time better perceived and more valid, than if the inspection were less carefully made. These may be classified into those having reference to the Patient, and into those to be observed by the Physician.

Rules relative to the Patient.—A. The part explored should be naked, or covered with some thin and pliable stuff, in order that the ear or the stethoscope may be exactly applied, and that the sounds may be easily transmitted. Thick garments, and especially those made of wool, prevent the respiratory murmur from being heard, except in the case of children, where it is very loud.

B. The individual to be examined, should be placed in a convenient position, which must vary according to his affection, and the regions of the body to be explored. This will be indicated in its proper place.

Rules relative to the Physician.—A. For the most part, the physician should place himself on the side which he wishes to examine; sometimes, for instance, in the case of the sounds of the heart, he will find it more convenient to be on the opposite side; in general he should explore on the right and left side without change of position; in doubtful cases, however, he will do well to change it. On the same side he will apply the one ear to the front and the other to the back, accustoming himself thus to the use of each organ indifferently.

B. Auscultation may be immediate or mediate, that is to say, made with the ear simply, or with the stethoscope. Laennec attaches too much importance to the use of the cylinder, which cannot be regarded in every way as an acoustic trumpet; if it have any of its properties, if it increase, as has been said, the strength of the sounds received by its excavated extremity, and concentrated by a narrowed tube, yet the limited amount of sounds collected under so small an area as that of the stethoscope, and the greater distance, are inconveniences which more than counterbalance such an advantage. The value of auscultation does not consist in the instrument, and the mechanical process adds nothing to the excellence of the method. The results are the same whether the sonorous phenomena, which pass in living bodies, be studied by the direct application of the ear or through the medium of a conducting body. Neither the one nor the other can be exclusively adopted; they both have their advantages, and the selection must depend on circumstances, which vary.

The *ear* perceives sounds over a greater extent of surface, because every part of the head, which is brought in contact with the chest, becomes, like the body itself, a conductor of sound. But immediate auscultation cannot be of constant and general use. The physician is not unfrequently prevented by the scruples of modesty, from applying his ear to the anterior part of the chest of a female. In certain regions, as the supra and subclavicular, those of the axilla and the groin, &c., the ear could with difficulty be closely applied, especially in the case of thin people, and when the person is dirty or covered with perspiration, immediate auscultation is at best disagreeable; though its inconveniences may in some measure be palliated, by the interposition of a linen cloth, between the ear and the walls of the thorax.

With the stethoscope, which, besides, is not always at one's disposal, the number of audible sounds, is smaller, but it has the advantage of being applicable to parts, to which it would

be difficult to apply the ear. It circumscribes the sounds better, and marks their limits with more precision. It is, however, true, that with a well-practised ear, the same end may be obtained. In short, mediate auscultation is not better than immediate, nor is the latter to be preferred to the former; they should by turns be employed by the physician, who would make an accurate and complete diagnosis, in order to prescribe a rational and efficient treatment. Their selection will vary, 1. *According to the individuals examined:* the stethoscope is almost inapplicable in the case of children, whom it frightens; it is preferable in that of females; in that of men its employment is a matter of indifference. 2. *According to the parts to be examined:* the ear comes in better contact with the posterior surface of the chest; for the anterior surface, their merits are nearly equal. The stethoscope is almost alone applicable to those parts of the body, which are depressed, and for the examination of certain organs, as the larynx, the trachea, the abdominal aorta, &c. 3. *According to the nature of the sounds:* for certain sonorous phenomena, the stethoscope has the advantage over the ear, and *vice versa:* the one is more suitable for more circumscribed alterations, as pulmonary apoplexy or caverns, while the other answers better for affections of greater extent, as bronchitis or pleurisy.

The form of the stethoscope, and the wood, of which it is made, are points of less importance than Laennec thought, if it be no longer considered as an acoustic trumpet, but as an instrument in some cases more serviceable than the ear, for the more it answers the condition of convenience, the better it will be. The original cylinder has now been generally abandoned, and the stethoscope of M. M. Louis and Piorry are preferred. These two instruments are composed of a hollow cylinder, from five and a-half to six inches long, widened at its base, narrower in its three upper fourths, and terminated superiorly by a disc of ivory, on which the ear rests.

These tubes have been subjected to numerous modifications. M. Piorry himself suggested the substitution of metal for wood, in order to diminish the dimensions of the cylinder. Some have invented bent stethoscopes, so that it might be possible to explore patients in every position, as also to perform the examination on one's own body. Others have added to the horizontal plate a projection, which might be introduced into the canal of the ear. All such improvements, and many others, which we shall notice, have more inconveniences than

advantages, and we believe it sufficient to be satisfied with the stethoscope we have described.*

If the ear be preferred for auscultation, it must be accurately applied, so that it may follow the movements of expansion and contraction of the chest, without producing any friction at the parts in contact. In using the stethoscope it should be held like a pen, and placed perpendicularly on the region to be examined, having, at the same time, for its point of support, an even surface, to which it is accurately applied; then, being thus held by the fingers, which remain immoveable, the pavilion of the ear is to be applied to the horizontal plate of the instrument; should air be allowed to enter, either between the skin and the stethoscope, or between this instrument and the ear of the observer, sounds will be produced, which may mask those of the part under examination. Pressure must be applied with moderation. If it be too great, it may, at the same time that it prevents the ear from hearing more perfectly, be painful to the patient, augment certain symptoms, as dyspnœa, &c., and sometimes change even the nature of the sounds.

The *two sides* should always be *comparatively explored.* Comparison alone will distinguish alterations which, being but little discernible, would otherwise escape observation. By thus having the unaffected regions for our type, the slightest anomalies occurring in the parts affected are, as it were, brought out into relief.

It is almost needless to add, that the physician should have every thing quiet around him; that he ought to listen for a sufficiently long time, and to abstract his attention, so as to isolate himself from what is passing foreign to his object, and to concentrate his attention on the pathological explanation of the sounds, which strike his ear. By dint of practice he acquires the habit, not only of being insensible to the different sounds made in the neighbourhood, but also of disengaging from several morbid phenomena the one, on which he ought chiefly to fix his attention.

Having established these principles, let us place the student at the patient's bed-side, and see, what moment he will select for examining him, how he will commence his examination, and how far he will deem it proper to conduct it; what precautions he will take in order to arrive, with as little delay and doubt as possible, at the knowledge of the sonorous phenomenon, and with what accuracy he will judge of its value.

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*Vide Appendix. Note B & C.

In general, we must pass from the simple to the compound, and, in the examination of physical signs, it is well to commence with those which it is easiest to appreciate. Thus, in regard to the chest, it is natural to examine first the conformation of the thorax and its movements, and to determine the amount of its sonority. The auscultation can then be proceeded in with the probability of losing as little time as possible in useless manipulation. The examination should be made as if the patient were not in a condition to reply to any question. If, however, he can give any information, it must be previously gathered, because it will serve to guide the observer, whom it may prevent from attaching undue importance to the employment of different physical modes of examination, and whom it may bring directly to his object, by indicating the apparatus or the portion of the apparatus which he ought first to explore. If he be led, for instance, to explore the chest, the presence of pain will inform him as to the side on which he will find the acoustic phenomena.

Let us now suppose, that he has applied his ear to the left side, how is he to judge, if he have had little experience of the nature of the sounds, which he hears? These, in fact, can take place in the œsophagus or stomach, in the circulatory system, or in the organs of respiration: in the last case they may depend on the sound of the voice, on coughing, or on respiration alone. The signs furnished by the voice, or by coughing, are so intimately connected with these acts, that it is difficult to mistake them, but it still remains to decide between the sounds of the air tubes, and of the heart or upper part of the digestive canal. The sounds of the œsophagus or of the stomach, have a tone quite peculiar; they are a kind of gurgling produced by gases. Then, in order to distinguish, if the phenomenon under investigation belong to the circulatory or respiratory system, the observer will ascertain, whether the sound be repeated sixty or eighty times, or only from sixteen to twenty times in a minute, and in general it will not be difficult to do so. But the phenomenon, whether depending on the action of the heart or lungs, may be manifest only at intervals, in which case, this rule is no longer applicable; he must, in these circumstances, ascertain, if it depend directly on the movements of respiration or of the heart, if it be connected by coincidence of synchronism with the dilatation of the chest, or with the pulsations of the radial artery. If its relation with the act of respiration be established, it must then be seen, wherein consists its difference from the normal

respiratory murmur, whether that be in relation to the force, rhythm or character: or whether, on the other hand, it constitute one of those abnormal sounds, designated râles; whether the râle be dry or moist: whether the bubbles be perceived during inspiration alone, or during both acts of the respiratory movements,—what is their size, their number, &c.

The sound in question will thus by degrees be recognized; but as several râles, for instance, the sub-crepitating râle, are perceptible in a considerable number of affections, the physician must not rest satisfied with having ascertained the existence of an acoustic phenomenon, in order to draw from it, inferences applicable to a definite diagnosis. He ought to appreciate its shades, its intensity, seat and extent: to elucidate it by the aid of accompanying stethoscopic signs: to take into consideration the functional symptoms both general and local, the circumstances under which disease was developed, what has been its progress, and, in fine, all the physiological and pathological conditions of the subject. It is only on the reunion of these different intervals, and on their careful comparison, that a sound diagnosis can be based.

DIVISION.

Auscultation may be applied to the *chest*, to the *neck*, to the *abdomen*, to the *head*, and to the *limbs*. In the four sections corresponding to this division, we shall treat successively of the different physiological and morbid phenomena furnished by the principal species of apparatus of the human economy.

FIRST SECTION.

AUSCULTATION OF THE CHEST.

Auscultation of the chest constitutes of itself almost the whole science of Stethoscopy, and comprises the alterations of organs, which, along with the brain, form the tripod of life. To facilitate its study, we shall separate the auscultation of the *Respiratory* from that of the *Circulatory Apparatus;* for though the derangements of these organs generally react reciprocally, yet their affections are not the less perfectly distinct, and the physical phenomena, which interpret their material lesions, constitute, in a like manner, two separate orders.

CHAPTER I.

AUSCULTATION OF THE RESPIRATORY APPARATUS.

Auscultation of the respiratory apparatus is made on the *chest* or on the laryngo-tracheal tube; and it has for its object the study of three orders of phenomena, furnished by the *respiratory murmur*, by the *voice*, and by the *cough*.

Art. I.—Respiratory Murmur.

§ 1. *Special Rules.*

When the modifications of respiration are the object of research, the *patient* is to be placed in positions varying with the parts of the chest to be examined. If it be the *anterior part*, he may stand with his arms hanging close to the trunk, or be seated, or in bed; but the *decubitus* on the back is preferable, as the chest rests then on a more fixed point of support. When the *posterior part* is examined, if the patient stand, or be seated in a chair, or, what is better, if he sit up

in his bed, he ought to cross his arms or hold them forwards. Sometimes, on account of great feebleness, he is made to lie on his abdomen, or rather on his side. At all events, the tension of the muscles should be moderate, and the position of the body symmetrical; the shoulders kept on a level, the head straight or slightly bent, sometimes backwards, sometimes forwards; occasionally it should be turned alternatively to the right or left, but always with the precaution to make the deplacement equal on either side, and to secure the reproduction of an exactly similar posture. In exploring the lateral regions, the patient must rest on the side opposite to the one to be examined: whether he be thus lying, sitting, or standing, the arm of the side under examination should be raised above the head, or sustained in the air by an assistant. Under certain circumstances the patient must be placed in other positions, as, for instance, on all fours, when it is wished to ascertain, if the fluid contained in the cavity of the pleura be displaced by such changes of position.

The patient should breathe on the one hand without any exaggerated effort, without making any noise with his mouth, and, on the other, without restraining his respiration—two extremes, into which he frequently falls by fear or ignorance, and under the impression that something extraordinary is expected on his part.

Thus the observer, lest he be deceived by a false appearance of respiration too weak or too strong, should always be careful to remark the manner, in which the movements of the thorax are executed. Sometimes it is necessary to hurry these movements, in order that the more rapid passage of the air may render the sonorous phenomena more distinct, or give rise to those, which otherwise would not take place; so that, in estimating the sounds, their share in the exaggeration may be noted. Some individuals cannot control their respiration, by quickening and moderating its movements at will; and in such cases they should be desired to cough during auscultation. Each fit of coughing will then be preceded and followed by a long inspiration, during which the acoustic phenomena will become more apparent. Some have advised, with the same view, that the patient should be made to speak or read several sentences continuously. In the case of children, it is very difficult to obtain spontaneously increased movements of respiration, and with them the cough will be more easily provoked. But, excepting such peculiar circumstances, requiring, so to speak, an excess of respiration,

it should, on the contrary, be as regular and natural as possible, because unseasonable efforts may tend to increase the intensity of the pain, or change the true characters of the sounds.

The *physician* should choose the most convenient position; for if he be awkwardly placed, it will be impossible for him to keep his ear invariably in contact with the different regions of the thorax. If his head be too low, the flow of blood will render his sense of hearing dull.

In choosing between the ear and the stethoscope, the point to be examined will decide him. For the upper and anterior parts, for the supra and subclavicular regions, the stethoscope is to be preferred; and is sometimes, in case of thin subjects, alone applicable. Lower down it is better to employ the ear; except in the case of some females, where the mammæ, on account of their volume, may be an impediment. On the back it is better to examine immediately, from the base of the chest to the spine of the scapula; for the cylinder cannot be well applied to a convex surface, and is apt to be displaced on the slightest movement of the thorax. In the supra-spinous fossa, when the patient is thin, the stethoscope will be used with greater advantage. For the lateral regions, the ear will be found to be more convenient, except for the hollow of the axilla.

In regard to the sound to be heard, although the cylinder be better for determining its seat, its precise limit and maximum of intensity, the ear will arrive by a little practice at the same result. In the cases of malformation of the chest of rachitic children, sometimes the stethoscope, and sometimes the ear may be most easily applied, according to the deformities of the parts. For a rapid examination the stethoscope is not at all convenient, for as it can cover only a limited surface, its employment would occupy too much time.

It is chiefly in regard to the chest that it is necessary to observe the important principle, that *auscultation should always be made on both sides, and in corresponding points of each side*. A single example is sufficient to show the importance of this precept. Supposing that there is a small effusion into one of the pleural cavities, giving rise on the affected side to a very slight diminution of the respiratory murmur, and on the healthy one to an increased or *peurile* respiration, one might be led to think, on an imperfect examination, that the disease is seated where the respiration is noisy, because it is supplementary, and, resting satisfied with this first observa-

tion, one might mistake for a sign of a disease that which is simply an excess of the normal type. The examination must also be made over the whole chest; and the observer should not give an opinion with inconsiderate haste, till he has explored each point during several inspirations.*

§ II. Physiological Phenomena.

The physiological phenomena of the respiratory murmur are of two orders, those furnished by the auscultation of the *thorax*, and those to be obtained by applying it to the *larynx* and *trachea*.

Normal Respiration.

Characters.—When the air-tubes are free, the lungs supple, elastic, compressible and expansible; when the air-cells are permeable to air, small, and with delicate walls; when the surface of the pleuræ is smooth, and their cavities empty;—finally, where the chest is in its normal condition, if the ear be applied to it during respiration, a slight murmur is heard, similar to that of a pair of bellows, the valve of which acts without noise; or, rather, it is analogous to the sound produced during a tranquil slumber, or by a deep sigh. This is the *natural respiratory sound*, called also the *vesicular sound*, *vesicular murmur.*

It is soft and gentle to the ear, much stronger and more prolonged during the dilatation of the chest, and more feeble and shorter during its contraction. It may be divided into two distinct sounds, that of inspiration and that of expiration, both continuous; if the difference of intensity and duration between the one and the other were to be represented by figures, the inspiration would† be to the expiration of 3 to 1. It is perceptible over all the chest, and possesses characters which differ according to the point, where it is heard, according to the fullness and frequency of the inspiration, according to the age and physical constitution of the individual examined. It is heard with more intensity in exploring regions of the chest, which correspond with denser and more superficial masses of pulmonary parenchyma, in the hollow of the axilla, and in the lateral, antero-superior, and postero-inferior parts of

*Vide Appendix. Note D.

†Vide Appendix. Note E.

the thorax. It is somewhat harsh, especially in thin people, at the bifurcation of the trachea, at the root of the bronchiæ, or, in other words, at the superior and middle regions of the back; and this harshness has gained for it the name of *normal bronchial respiration.* It must not be thought, however, that this bronchial respiration exists always in that quarter, and that it is distinguished by any marked difference from the respiration of other regions, for the best exercised ear can very frequently appreciate no sensible shade. The respiratory murmur is equal on both sides of the chest, though there are cases where, in the upper part of the lung, a little difference has been remarked. M. Gerhard of Philadelphia, endeavoured to explain this phenomenon by the larger dimension of the right bronchia. According to the measurements of M. Fournet, this anatomical difference is too slight to have any real influence in its production. Without wishing to deny its existence, we do not consider it pronounced with sufficient distinctness to convey to the ear in *every* case any appreciable sign. It is well known, besides, that the increase of the caliber of the bronchiæ contributes much less to the bronchial character of respiration, than the induration of the parenchyma around the dilated tubes, of which hooping-cough furnishes an evident proof, where dilatations of the bronchiæ are by no means uncommon, while during life they are rarely to be detected by the bronchial blowing. It results from this identity of vesicular murmur on the right and left side, that even a slight dissimilarity between the sounds, at the apex of the two lungs, is the sign of a pathological condition, all the more valuable when it is found on the left side.

When the respiration is full and rapid, the respiratory murmur increases in degree and duration, but if there be only an acceleration of the movements of the chest, its intensity is greater, while its duration is shorter. It is louder in the majority of children; and when in their case it has not the *peurile* character, and does not differ from the respiration of adults, the cause of such anomaly is to be found in the number of inspirations being smaller than they generally are in childhood. The principal cause of *puerile respiration* appears, therefore, to be the acceleration of the respiratory movements (of which the average is about 24 in a minute,) and at the same time their greater fullness. The inconsiderable thickness of the walls of the chest, and of their muscular coverings, may be another cause as well as the structure of the lung, and the greater need of air, peculiar, as some physiolo-

gists think, to that period of life. In adults the vesicular murmur is more feeble, and much more so in old age. Some old people seem, nevertheless, to exhibit in the absence of any pathological condition, a respiration resembling that of children. M. Andral explains those differences in the intensity of the respiratory murmur, by alterations in the structure of the lungs, the tissue of which becomes rarefied as man approaches the natural limit of his career, so that a certain number of air-cells being united together by the atrophy and disappearance of the vesicular walls, the surface over which the air has to expand is diminished in extent.

The respiratory murmur is stronger in thin individuals, whose chest is wide, its walls being but little covered with muscle, and it is weaker in stout people, who have the thorax narrow, or still more so when its walls are thick, whether caused by the developement of muscular or adipose tissue, or by an œdematous infiltration. Independently of the causes already mentioned, certain individual conditions, of which observers can give no explanation, cause, as Laennec has remarked, the degree of vesicular murmur to vary. Some accidental influences increase its force, such as bodily exertion, moral emotions, &c.

Differential Diagnosis.—Sometimes, on applying the ear to the naked chest, a sound is heard not unlike the distant rolling of a heavy carriage, which for an instant might be mistaken for that of respiration; but this sound, which has been attributed to the contractions of the muscles of the chest, and termed *rotatory*, is distinguished by a character of permanence that does not belong to the vesicular murmur, composed as the latter is of two periods of unequal duration and force. In other circumstances, if the first inspiration be full and rapid, a fine crepitating sound is heard instead of the soft uniform murmur, which cannot be perceived in the succeeding inspirations. May not this phenomenon, observed by M. Andral and other authors, and more than once noted by ourselves, be caused by the sudden unfolding of the pulmonary cells?

When, instead of examining the chest, the stethoscope is placed on the *trachea*, a harsher and more instense sound is heard in the two periods of respiration, called the *tracheal respiratory murmur*. On the larynx itself this murmur also varies, resembling the kind of blowing produced by the passage of air into a large cavity. Moreover, in addition to its

harshness, its cavernous character is considerably more developed, and constitutes the *laryngeal respiratory sound.*

What is the cause and seat of the respiratory mumur?

Before replying to this question, let us first call to mind several conditions, which, according to our observation, appear to influence the intensity and nature of the respiratory sound. Such are the quantity of air put in motion in the air tubes, and the rapidity of its passage through them, the degree of elasticity of the parts which it traverses, and the density of the surrounding media; the caliber of the bronchia, especially the state of partial tumefaction in which these may exist,—the proximity or distance from the surface of the lungs, and, in the last place, the presence or absence of accessary sounds.

The respiratory murmur has been explained in two ways: Laennec attributed it to the passage of air through the air tubes, and to the vibrations thereby produced in their different parts, and this theory was generally admitted to be the most natural and most consonant with facts, when M. Beau announced a contrary opinion. He considers the respiratory murmur as nothing else than the *resonance of the sound which takes place at the back of the throat during the two acts of respiration*, and, in support of his explanation, adverts to the following observations:

1. During respiration a slight noise is produced in the back of the mouth, whether the individual expires or inspires, and, on auscultation, the tracheal and vesicular sounds are found to have the same relative intensity as that produced in the throat, though they are somewhat different in kind.

2. When the guttural sound is suspended, (which can easily be done by instinctive dilatation of the upper part of the air passages), the tracheal and vesicular sounds exist no longer. Respiration, although silent, is performed as usual, and if we did not perceive the walls of the chest alternately rising and sinking under the ear, we might be led to believe that the individual whom we examine, does not breathe at all.

3. If the guttural sound be suspended during one of the two respiratory movements, whether of expiration or inspiration, no tracheal or vesicular sound is heard during the movement unaccompanied by the noise in the back of the throat.

4. If a noise be made with the lips, so as to blow during expiration, and produce a hissing sound in inspiration, the same kind of sound is heard in trachea and cells; but the noise thus made is altogether exterior, there is more resonance in the surrounding air than in that contained in the air passages; the sound is also better heard by the ear, which is disengaged, than by the one occupied in auscultation. The contrary is remarked in the ordinary guttural sound, which, being deeper, produces more resonance in the respiratory organs than in the external air.

5. If a thin sheet of paper, rolled into the form of a tube, of sufficient caliber, be through the orifice formed by the open lips, introduced into an individual's mouth, till one end, directed towards the isthmus of the fauces, be advanced half the length of the tongue, and if, in this position, respiration be performed freely and fully, without attempting to suspend the guttural noise, the tracheal and vesicular sounds will be heard as usual. If the breath be restrained, after a long inspiration, and the moment be seized by some one to blow through the tube against the back of the mouth, the tracheal and vesicular respiratory murmurs will be heard "as when respiration is performed naturally."

We cannot admit, without restriction, the conclusions which M. Beau deduces from these experiments.* The production of a noise habitually formed at the back of the mouth,—the habitual relation between its intensity and that of the tracheal and vesicular sounds, are incontestible. But is that sufficient to prove, that the latter is really the resonance of the former? are not the rapidity and force of the inspirations, which, for the most part, increase the guttural sound, conditions, that also augment the respiratory murmur in the air passages by quickening, at the same time, the passage of the air through their divisions?† The results of observation confirm this view. The more slowly respiration is performed, the more feeble is the vesicular murmur; the more rapid it is (provided the lungs are always sufficiently distended), the greater is its intensity. Nor do we admit the *constancy* or *absolute necessity* of a relation existing between the guttural and pulmonary sounds. We find, in reality, though M. Beau asserts the contrary, that in certain individuals affected with pulmonary emphysema, the respiratory murmur is very weak, or scarcely perceptible, while a sound of considerable inten-

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*See Note F. †See note G.

sity is produced at the upper part of the air passages. In others a principal air tube may be narrowed, and respiration disappear in that portion of the lung, to which its branches are distributed, while the guttural sound is perceived in the same region as distinctly as it is in the rest of the lung. One of us (Archives Juillet, 1835), has given several cases where in auscultation of the larynx a loud noise was heard, but, on examining the chest there seemed to be more or less complete absence of respiration, (Obs. III. and VIII.) We have even quoted some cases of obstruction of the upper part of the air tubes, where the laryngeal sounds were sufficiently loud to be heard at some distance, while there was almost no vesicular murmur; but, subsequently, the pulmonary respiration became gradually more distinct in proportion as the laryngeal sound lost in intensity.

The second and third propositions of M. Beau are equally questionable. Although the guttural sound is suspended, the pulmonary one does not cease to be perceptible, unless respiration be performed slowly and with little energy; and, in this case, does not the silence depend upon the fact, that the air enters with less rapidity into the pulmonary cells, and that it dilates them less completely? If the individual, without making any noise in the back of his mouth, breathe freely and quickly enough to cause the air to enter into the cells in sufficient quantity, and with sufficient rapidity, then the respiratory murmur is quite distinctly heard.

As regards his fourth proposition, we do not deny the possibility of perceiving, on exploring the chest, noises, which are produced at the aperture of the mouth, in the same manner as abnormal laryngeal sounds are heard in cases of stricture of the larynx, in croup, &c.; but with a little practice these can be easily distinguished from the vesicular murmur, and are recognised by their distant character, while the latter seems to be produced under the ear itself. These different sensations can be so isolated, that in the same part of the chest the laryngeal may be simultaneously distinguished from the pulmonary sounds.

We have repeated the experiments of M. Beau on different occasions, and under exactly similar conditions, in order to judge of the value of his fifth proposition, and we, as well as M.M. Raciborski and Fournet, have obtained results quite different from those, which he brings forwards in support of his hypothesis.

Several other statements made by M. Beau appear to have

no better foundation than the preceding. Thus he endeavors to strengthen his theory by the analogy which exists between the resonance of the voice and the respiratory murmur—both having their origin at the upper part of the air passages, and both being propagated downward like an echo. But the comparison of two phenomena, of so different intensities, is essentially faulty; for however feeble the voice may be, it causes vibrations in the walls of the thorax, while nothing of the kind takes place in the case of the respiratory murmur. A much greater difference characterises the two phenomena, and proves that there is no similarity in their mode of production. The sound of the voice as well as that, properly speaking, produced by the larynx, cheeks, and throat, diminishes in intensity, according to the squares of the distances; and the farther from the larynx auscultation is made, the less perceptible are the vibrations, which are not so distinctly heard at the base as at the apex of the chest; whereas the respiratory murmur is as strong at the base as at the summit, provided auscultation be made on a point of the chest, corresponding to a sufficient mass of pulmonary parenchyma. It cannot therefore, like the resonance of the voice, be the weakened transmission of a distant sound.

The respiratory murmur is not "the effect of resonance in the whole column of air inspired and expired, nor of the noise resulting from the impulse of that column against the velum palati or the neighbouring parts;" for in a patient alluded to by M. Fournet (*loco cit.* page 336), the destruction of the velum palati did not in the least change the sounds.

M. Beau admits that the shock of the column of air against the two sides of the nasal and buccal cavities, as also against the edges of the glottis, may concur in producing the phenomenon; but do we not see individuals affected with diseases of the larynx, where the upper part of the air-tubes has become impermeable to air, but where, notwithstanding, the normal vesicular murmur is heard after the operation of tracheotomy? One of us has related a case (*loco cit.*), of a patient in whom the trachea was opened: before the operation the laryngeal sound was very loud, and the pulmonary one silent; but, after its performance, no noise was heard at the back of the mouth, nor at the glottis, while the vesicular murmur was very distinct. It is in vain to object, in this case, that the noise, produced at the surface of the canula, acted as a substitute to that otherwise taking place at the glottis, or isthmus faucium. This could not be the fact, for

the pulmonary sound was identical with the normal vesicular murmur, although the noise produced by the passage of the air through the metallic tube was quite different from that ordinarily produced in the cavity of the pharynx. Let us add, also, that these two species of sounds are appreciable at the same instant; and that in the case of several patients observed by us or M. Fournet, it was easy, in auscultating the chest, to distinguish, under the ear, the soft murmur of respiration, and, at the greater distance, the metallic sound produced by the pressure of the air through the canula.

Shall we readily admit the other statement, that the *bronchial blowing* is not clearly perceived, except in the absence of the vesicular murmur, caused by the impermeability of the surrounding air-cells. It is true that this absence is favorable to its being heard; but that is not the only cause of tubular blowing; and M. Beau seems to lose sight of the changes occurring in the bronchiæ, which, surrounded by a firmer tissue, present, on that account, conditions better suited for producing vibrations, since the intensity of bronchial respiration is observed to increase exactly in proportion to the density of the hepatised parenchyma. Besides, in those circumstances where the blowing is heard (pneumonia, pleuro-pneumonia), the movements of the chest are accelerated, and the quickness of the passage of the air is a new condition, capable of adding to the force of the sounds.

M. Beau is of opinion, *that the loud respiration of pneumonic patients and of children*, cannot be explained by Laennec's theory: and he thinks it depends upon the increased guttural sound, which is caused by the frequency and quickness of respiration. It must, however, be remembered, that the intensity of the respiratory murmur may be owing to this very frequency and quickness, and that, in the case of pneumonic patients, an increased quantity of air enters the sound lung, on account of the deficient capacity of the hepatised portions.

Laennec thought that when, in some asthmatic patients, the vesicular murmur was inaudible, the silence was owing to the air not entering the lung; but M. Beau doubts the conclusion, and maintains that the silence is caused by the absence of the sounds in the throat. This latter opinion is, however, contradicted by daily observation. We repeat that, on the one hand, many asthmatic patients make much noise during respiration, although in them the vesicular murmur is

silent ;* and, on the other hand, that, in the normal state, the vesicular murmur may be perceived during absence of the noise produced at the back of the throat. The weakness of respiration in emphysema may also, to a certain extent, be accounted for by the fact, that the cells are not completely emptied of the air, which they contain, so that its circulation becomes, less complete, on account of the impediments to its renewal. That such a stagnation of the air does take place is sufficiently proved by the slight collapse of the lungs on opening the chest.

M. Beau seems also to be mistaken, when he speaks of the remarkable dilatation of the chest during respiration in asthmatic patients. The chest is habitually dilated in emphysema, so that, to increase its dimensions still farther, and favour the entrance of air into the lungs, the patient has recourse to great efforts; in spite of which, however, he can, with difficulty, effect the enlargement of the cavity of the thorax. His explanation of the cause of the diminished respiratory murmur, during the act of breathlessness, which follows violent exercise, appears to us equally questionable. It is not the fact that, in such a case, the expiration alone is noisy, and that, during inspiration, *no* pulmonary sound is heard. If, in these circumstances, the vesicular murmur be less distinct, might not the phenomenon depend on a more hurried respiration, during which the air does not quite penetrate to the cells on the surface of the lungs, or dilates only a limited number of them? We see, for instance, that in some very painful cases of pleurodynia, the weakness of the respiratory murmur is explicable by the incomplete dilatation of the chest. It is, however, distinctly perceived as soon as the patient takes a deep breath.

M. Beau questions, moreover, the theory of Laennec regarding the existence of the conditions capable of producing aerial vibrations and friction upon the smooth, even, and soft membrane of the bronchiæ. It must, however, be remembered, that besides those parts of the air-tubes which are formed solely by membranes, there are others furnished with cartilages. That the caliber of the smaller bronchial ramifications varies alternately during the expansion and contraction of the pulmonary apparatus,—that the bronchial tubes present, in their innumerable divisions, an infinity of small breakers or points on which the column of air is split, and, finally,

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* See Note H.

that the unfolding of the pulmonary cells may, itself, perform a part in producing the respiratory murmur. But, whatever these conditions may be, direct experiment proves that noises can take place in the bronchia and cells without the co-operation of the superior parts of the air-tube. M. M. Raciborski and Pelletier, after having established the fact, that the section of the trachea of a living rabbit did not prevent them from hearing a sound similar to what they had observed previous to the operation, (although respiration was not performed, as usual, by the upper part of the air-canal), "put the animal to death, and then imitated, by means of a small tin canula, the process of respiration, taking care, at the same time, to make no noise with the mouth. The sound produced, under these conditions, was exactly similar to that heard during life." We have, ourselves, made analogous experiments, on lungs removed from the chest, by introducing into the trachea a tube of glass of nearly equal dimensions; on blowing slowly and gently through the tube no sound reached the ear through the stethoscope applied to the lung; but on blowing with greater force and rapidity, so as to dilate the cells near the surface of the lungs, a sound was transmitted analogous to the natural respiratory murmur. "It is in the same way possible to reproduce, at will, the bronchial sound by blowing into the bronchiæ when separated from the pulmonary tissue, or in another manner, by blowing into these tubes, after having converted the lung into a solid mass, by injecting greasy matter into its substance."—(Fournet.)

Let us advert, for a moment, to the practical consequences of M. Beau's theory. We agree with him, and with every other person, that, in order to hear the abnormal sounds of the lungs, the pleuræ, or the heart, it is of advantage to cause the patient to breathe without making any noise at the back of his mouth, because the guttural sound would prevent us from properly appreciating the others; but this is an universal principle of remarkable simplicity, and one of very easy demonstration. It is obvious that, whatever theory we may adopt, any one sound is more distinctly heard by subduing the others. It is on this account that we beg the patient to breathe gently, in order to perceive more distinctly the sounds of the heart, and that we enjoin another to make no guttural noise, that we may more distinctly hear certain pulmonary râles; but, in this latter case, it is not the vesicular murmur, we wish to arrest, for its cessation would, at the same time, involve that of the râle, which cannot be produced except by the entrance of air into the lung.

In summing up this long discussion, which the elaborate exposition into which M. Beau has entered, has in some degree rendered necessary, let us call to mind the chief propositions which invalidate his theory: 1. The guttural sound is heard the more distinctly the nearer we examine to the seat of its production, while the vesicular murmur is equally well heard in every point, where there is a sufficient mass of pulmonary tissue. 2. The guttural sound may be strong, and yet the vesicular murmur absent; and, on the other hand, the vesicular murmur may be pure, clear, and distinct, without the perceptible existence of any noise at the back of the mouth. 3. An observer, who has had a little practice, can recognise the production of the guttural sound, at a distance, while the respiratory murmur takes place immediately under his ear. 4. When a given point of the chest is explored, the two sounds may be distinguished from each other although they exist simultaneously.

Without denying, therefore, the habitual relation existing between the sounds produced in the higher and those produced in the lower portions of the air-tubes, we think it beyond doubt that, during the act of respiration, a sound is produced in the different parts of the pulmonary system, which varies according to their difference of texture, (*laryngeal* in the larynx, *tracheal* in the trachea, *bronchial* in the bronchiæ, and *vesicular* in the air-cell); * that this sound, whatever may be the mechanism of its production, (vibrations, frictions, &c.) † is caused by the passage of air througn the different portiont of the respiratory apparatus.

In reliance upon these principles for the indication of the diagnostic signs, which can be drawn from the respiratory murmur, we hold, that its presence or absence announces the permeability or impermeability of the air-tubes, and that if it possess its natural characters of purity, softness, and intensity, it indicates the physiological condition of the pulmonary system. It should not be forgotten, however, that auscultation sometimes discovers no change in the character of the respiratory murmur, although there may exist some lesion of the pulmonary tissue, provided such lesion, limited to a small extent, and being situated in the centre of the lung, be surrounded by sound parenchyma, which smothers, so to speak, the plaintive cries of the affected organ.‡

*See Note I. †See Note K. ‡See Note L.

III.—Pathological Phenomena.

We have seen what are the characters of the normal respiratory murmur, when the lungs present all the conditions of their physiological state. And we now proceed to examine the very variable modifications, which the respiratory murmur will undergo, if one or more of these conditions be altered. If the air arrive more rapidly, and more abundantly, at one portion of the lung than at the other; if the action of one lobe be increased, to compensate for the inaction of another, the natural sound will appear exaggerated on exploring the corresponding part of the chest, and thus become *loud respiration.* When the number of pulmonary cells is less considerable, when they are less permeable to air, or when the lung is more distant from the ear, the respiration will be *feeble*, if these conditions be still more pronounced, and the cells be altogether impermeable, then the vesicular murmur will be *absent.* If the movements of the chest be accelerated, the respiration will be *frequent*, if they be the contrary, it will be *rare;* if the air, instead of entering the cells continuously, appear to fill them in an interrupted current, it will be *abrupt.* It will be *long*, if the pulmonary expansion be gradual and slow; *short*, if the air be rapidly inspired and immediately expired; and if the elastic fluid be inspired slowly, at the same time that lesions exist capable of augmenting the noise, *prolonged expiration* will be heard. When the air passages become modified in their diameter, or the pulmonary tissue in its density, the respiration will present differences in force and tone, proportional to the amount of these lesions:—thus, if the pulmonary parenchyma have lost its suppleness by thickening of the walls of the air-cells, or by the deposition of tubercles, respiration will become *harsh.* If the density be greater in consequence of the obliteration of the cells, if the bronchiæ be alone permeable to air, and form tubes with more solid walls, the respiration will be *tubular* or *bronchial.* If the bronchiæ be considerably dilated, or if cavities exist in the lungs, it will be *cavernous*, and when these caverns become very large, or, when the air, in consequence of a perforation of the lung, enters into the pleural cavity, the tone will be still more hollow and resonant, becoming thus *amphoric* respiration.

The morbid conditions just enumerated, modify the respiratory sound in its force and in its tone, but notwithstanding such alterations it is still to be recognised. In some other

lesions of the respiratory organs, it is only heard at intervals, and, either simultaneously with it or as its substitute, acoustic phenomena are perceived, called more specially *abnormal sounds* (*bruits anormaux*). Thus, if the pleura be covered with false membranes, the movements of the lung as it changes its position during respiration, give rise to a true sound of friction (*bruit de frottement*); if the mucous membrane of the bronchiæ be swollen; if the interior of their canals be lined or obstructed by mucous secretion, and if various kinds of folds, vibrating cords or bubbles, be then formed, râles will be produced, sometimes dry (*sibilous* or *snoring*) sometimes moist (*crepitating*, *subcrepitating*, *cavernous*). Finally, other circumstances may give rise to sounds, the character and value of which are not very precisely determined, and which authors have variously designated (*crackling*, *rubbing*, *&c.*)*

On taking a retrospect of the different pathological modifications now enumerated, we find it easy to arrange the respiratory sounds into four divisions:—

1. *Alterations in intensity.*
2. ——— *in rhythm.*
3. ——— *in character.*
4. ——— *caused by abnormal sounds.*

This division is based on the observation of facts, and we therefore adopt it as at once the most natural and most practical. We shall begin with the morbid modifications of the respiratory murmur, in reference to the thorax: those of laryngeal and tracheal respiration shall be treated of in a separate section.

*See Note M.

I. TABLE OF THE ALTERATIONS IN THE RESPIRATORY SOUNDS.

ALTERATIONS OF RESPIRATORY SOUNDS.	I. IN INTENSITY		*A.* Loud respiration. *B.* Feeble respiration. *C.* Absent respiration.
	II. IN RHYTHM.	1. Frequency.	Frequent respiration. Rare respiration.
		2. Continuity.	Abrupt respiration.
		3. Duration.	Long respiration. Short respiration. Prolonged expiration.
	III. IN CHARACTER		*A.* Harsh respiration. *B.* Bronchial respiration. *C.* Cavernous respiration. *D.* Amphoric respiration.
	IV. ABNORMAL SOUNDS.	1st kind.	Sound of friction.
		2d kind.	Râles.

I. Alterations in the Intensity of the Respiratory Murmur.

Viewed in this light, the respiratory sound may be increased (*loud respiration*), diminished (*feeble respiration*), and this diminution may terminate in complete abolition (*absence or silence of the respiratory murmur*).

A. *Loud Respiration.*

Synonymes.—Puerile, exaggerated, supplementary, hypervesicular.

Characters.—Loud or *puerile* respiration consists in a vesicular murmur of greater intensity, than what is heard in the normal state, whilst it preserves the soft and gentle character of natural respiration. Inspiration and expiration become more noisy: and the absolute duration of the two periods is increased, while their relative duration continues the same. The seat and extent of puerile respiration vary, but for the most part it occupies the whole surface of one side of the chest.

Differential diagnosis.—It is possible to confound *strong* respiration with the *natural* respiratory murmur, when the latter is increased by any physiological cause; with harsh, and even sometimes with *bronchial* or *cavernous* respiration.

As the intensity of the vesicular murmur varies according to the individual, his age, and the degree of energy and activity of the inspiratory movements, it is easy to perceive that, strictly speaking, it may not always be easy to decide, if the increase depend on a physiological or morbid cause. Comparison will lead us to determine this point. The natural sound augmented by a physiological cause, is perceived throughout the whole extent of both sides of the chest; but the *loud* respiration is only heard in one point of one or both lungs, while pathological phenomena present themselves at other points. The *harsh* respiration is to be distinguished from the *supplementary* by a relatively longer duration of the expiratory sound, or by the coincidence of other stethoscopic signs, or by some change in the sonority of the thorax. A similar coincidence will distinguish the *bronchial* from *cavernous* respiration even in those cases, where their tone may not be sufficient to characterise them.

Physical cause.—The increase in the intensity of the vesicular murmur appears to be owing to the admission of a

greater quantity of air into the corresponding parts of the lungs, to its more rapid circulation there, and, perhaps, to the dilatation of a greater number of air cells, if we admit with M. Cruveilhier, that in the physiological state the vesicles are not all distended at each inspiration.

Pathological signification.—When a pleuritic effusion compresses one of the lungs, the other will take on a supplementary action; when tubercles, deposited at the apex of the organ, render a certain number of air cells less permeable, the other portion of the lungs will, to a certain extent, compensate for this deficiency of action, and so on. When, in short, the respiratory act is by any cause whatever, altered in one part of the chest, a supplementary respiration may take place in the other portions; and thus the augmentation of the vesicular murmur, announces some affection or other of the organs of respiration in a part more or less distant, from where it is heard. It assists the diagnosis in an indirect manner, by putting us on the track of the existence of some morbid state, which may be characterised by other and more positive symptoms; for instance, in some cases of central pneumonia, it may be distinguished several days before inflammation is announced by pathognomonic signs.

Conclusion : Semeiological value.—The loud respiration indicates the existence of disease, but without determining its seat or its nature. Its importance to diagnosis is, therefore, not considerable.

B. *Feeble Respiration.*

Character.—The degrees of feeble respiration vary from that of slight diminution to almost complete silence. It is manifested generally in both periods of respiration, but chiefly during the first. When it is thus feeble it is almost always at the same time shorter. In some cases its natural softness is not lost, while in others it becomes somewhat harsh. At one time it appears to take place in the immediate vicinity of the ear, as in the natural state, at another it appears more distant. Its seat is variable, occupying either a limited point, or extending more or less over one or both sides of the chest. It is sometimes transient and mobile, but for the most part it is permanent and fixed in the region, where it is observed.

Physical cause.—Feeble respiratory murmur depends upon two orders of causes, which act either together or separately. Either it reaches the ear less easily on account of some solid

body or fluid causing a greater space than usual between the lung and the walls of the chest; or the respiratory murmur itself is produced with less intensity. The physical conditions giving rise to such diminution of intensity, are incomplete dilatation of the thorax,*—the admission of a diminished quantity of air into the lung,† in consequence of some obstacle to its passage in the larynx or bronchiæ, a slower circulation of the elastic fluid, which thus does not reach the surface of the lungs, an imperfect permeability of the air-cells.

Pathological signification.—The lesions belonging to the first order of causes are: *pleuritic effusions*, at their commencement, and at their decline,—pulmonary adhesions caused by thick false membranes, with or without consecutive contraction of the thorax.

To the second category belong intense *pleurodynia*, where pain counteracts complete dilatation of the chest; certain diseases of the larynx (See *Auscultation of the Larynx*) partial obstruction of one or several branches of the bronchia, caused by a collection of mucus, by the presence of a foreign body, by the *narrowing* of their caliber, or by the *compression* of their walls by tumours of different kinds. In some cases of pulmonary phthisis, the feeble respiratory murmur can be referred to no other cause: the bronchial ganglions affected with tubercle being augmented in bulk, and thus causing a narrowing of the bronchial tubes. The reality of this fact is put beyond doubt, by a case observed by one of us in the Hospital of la Charité.

"A young man, aged 17, presented the general symptoms of a tubercular affection; the left subclavicular and supraspinous regions were dull on percussion, and in these points the respiratory murmur was almost absent. The idea of a circumscribed effusion at the summit of the chest could scarcely be entertained, as this fluid rarely presents such a disposition; or of crude tubercles with thickened parenchyma, since such morbid conditions proclaim themselves rather by a harsh or bronchial respiration. We came to the conclusion, that there existed stricture of the bronchia, which ramified in the apex of the left lung. The patient died eight days subsequently, of profuse hæmoptysis, and at the autopsy, this bronchia was found to be compressed by large tubercular ganglions, and to such an extent were its walls corrugated, that its surface had scarcely the diameter of a goose quill."

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*See Note N. †See Note O.

In the same section will be comprehended *pulmonary emphysema*, in which a certain number of cells, already filled with air, are incapable of receiving more of the elastic fluid; *phthisis in the first stage*, where tubercular infiltration compresses the surrounding tissue, and, consequently, diminishes the number of permeable air-cells, finally, certain very rare degenerations, as *cancer*, *melanosis*, &c.

In other circumstances, feebleness of the respiratory murmur may depend upon some mechanical pressure made upon the pulmonary parenchyma, whether internally (*aneurisms of the aorta*, *hydropericarditis*, &c.) or externally, (*rachitic deformities*, *abdominal tumors*, *ascites*, *hypertrophy of the liver*, &c.)

Analytical Diagnosis.—As the affections, in which the *feeble* respiratory murmur may be perceived, are very numerous, the diagnosis should be grounded on an exact analysis of the characters of the phenomenon, its seat, its extent, its progress, its duration, the accessory stethoscopic signs, and, finally, the local and general circumstances, under which it shows itself.*

When *feeble respiration* is perceived at the lower parts of the chest, giving to the ear the sensation of distance, and coinciding, at the same time, with dulness on percussion, it indicates *pleuritic effusion*, or, which is more rare, the presence *of thick false membranes*, infiltrated with serosity or tubercular matter. If it exist simultaneously with a sharp pain in the mammary region, with diminished dilatation of the chest, without any change in its *sonority*, and if fever be not present, it will rather depend upon a *pleurodynia*. If there be *general* diminution of the respiratory murmur with increased efforts of inspiration, while the normal sonority continues, there probably exists *some obstacle to the free introduction of air into the upper part of the air-tubes*, (See *Auscult. of the Larynx*.) If it be limited and transient, ceasing after fits of coughing, and alternating with the sub-crepitating râle, *bronchitis* may be diagnosed. Where it is intermittent and mobile, if the history of the case lead to the presumption, that a *foreign body* has been introduced into the air-tubes, it will indicate the movements of that body. When it is permanent, continuing several months without presenting any remarkable alteration in the local signs, in the general symptoms, or in the sonority, it will indicate stricture of the bronchiæ. When it extends over a considerable surface of one

*See Note P.

or both sides of the chest, especially if its seat correspond with the situation of the free edges of the lungs, and be accompanied by a sibilous râle, and a bulging of the thoracic walls, with increased sonority, pulmonary emphysema is probably present. If it be limited to the apex of the lungs, accompanied by dulness on percussion, we may presume the presence of tubercles in their crude stage.

In regard to feebleness of respiration caused by cancer, melanosis, rachitic deformity, or by abdominal tumors pressing up the lung, &c., the determining cause will be judged of by the mode of exclusion, by direct inspection, or by the examination of such phenomena as the other organs may present.

Conclusion: Semeiological value.—Of all the affections, which we have just enumerated, and which often proclaim themselves by feeble respiration, the physician ought to turn his attention almost exclusively to tubercles, pulmonary emphysema, and pleurisy with effusion, being by far the most frequent, (bronchitis, which is also common, has its own special râles.) Emphysema is present, if a feeble respiratory murmur coincide with increased sonority; there will be tubercles or pleuritic effusion, if it coincide with dulness on percussion. When feeble respiration, accompanied by dulness on percussion, is limited to the apex of the lung, it is probable that tubercles exist; if it be circumscribed and situated in the lower part of the chest, pleuritic effusion may be more readily presumed. If it be present in the apex of both lungs, it is almost certain that there are tubercles on both sides; if at the base of both lungs, there is double pleurisy, or double hydrothorax.*

C. *Absent Respiration.*

Synonymes.—Absence of respiratory murmur, silence, silent respiration.

Characters.—Respiration is said to be absent, when the ear applied to the chest can perceive no sound whatever. In certain pathological conditions, râles, instead of the vesicular murmur, are heard, or an abnormal bronchial, cavernous, or amphoric respiration. (See these words.) But this is not the case in silent respiration, where the murmur is altogether wanting, and no sound is heard in its stead, the silence being complete. Moreover, the absence, like the feebleness of respiration, can be ascertained in various points, and may be local or general, momentary or permanent.

*See Note R.

Physical cause.—A greater degree of the same physical causes, which render respiration feeble, may also produce its absence. Either the vesicular murmur does not take place in consequence of the impermeability of the air-cells, or of some obstacle to the passage of the air into the bronchia, (whether that be seated quite at their upper part or lower down); or, on the other hand, the sound, which may still be produced, is not heard on auscultation, on account of its distance from the ear, the lung being pressed inwards by liquid or gas.

Pathological signification.—The indication of disease is almost the same in absence and in feebleness of respiration, with the exception that silence indicates a more advanced state of abnormal lesion. Thus the respiratory murmur, instead of being merely diminished, is absent in pulmonary emphysema, when a very considerable number of the cells are impermeable to air; in certain cases of phthisis, where there is deposition of tubercles in voluminous masses in the substance of the parenchyma; in affections of the larynx and trachea, when the occlusion of the air-passages is great; in obstructions of the bronchiæ, by foreign bodies arrested in their interior, in obliteration of these passages: in copious pleuritic effusions, and in simple pneumothorax: pathological conditions, in which a portion of the pulmonary tissue, mechanically compressed by a liquid, by a gas, or by both at the same time, become impermeable to air.

Aanlytical Diagnosis.—This rests upon considerations precisely similar to those, which we have detailed when speaking of the morbid signification of feeble respiration. All that was then said of the latter ought now to be repeated in the case of silent respiration, with the addition that pulmonary emphysema is rarely so considerable as to cause absence of respiratory murmur, and that tubercles deposited in voluminous masses proclaim themselves rather by bronchial respiration than by the absence of the vesicular murmur, (see bronchial respiration.) If, however, there be pleuritic effusion, there is almost always complete silence; and pneumothorax should be diagnosed, if the respiratory murmur be absent only on one side of the chest, with coincidence of vaulted figure of its walls and tympanitic sonority.

Conclusion: Semeiological value.—Complete silence of the respiratory murmur being almost exceptional in emphysema and in tubercles,—diseases of the larynx being accompanied by particular phenomena,—obliteration of the bronchiæ, and their obstruction by foreign bodies, as well as pneumothorax,

rare affections when compared with pleuritic effusions, it follows that silent respiration is a very valuable sign. If its existence can be ascertained on one side in the central region or at the two inferior thirds of the chest, along with dulness on percussion, it indicates, almost infallibly, pleurisy with effusion, and if on both sides, an accumulation of serosity, in both cavities of the pleura, either with or without inflammation. In some far less common cases, the silence is complete, even over the whole extent of one side of the chest. If there exist, along with this, dulness on percussion, a copious liquid effusion is certain; and, if there be tympanitic sonority, the effusion will be gaseous.

II. Alterations in Rhythm.

These alterations may refer to frequency, continuity, or duration of respiration.

1. *Frequency.*

In the physiological condition, the number of inspirations made by an adult or old person, ranges from eighteen to twenty-two in a minute; and, in a child, from twenty-two to twenty-six. In disease this number may be smaller, and fall as low as twelve, or even seven or eight; but more frequently it is greater, and rises to thirty, forty, sixty, eighty, and we have several times seen it above a hundred, in children suffering under double pneumonia.

These different degrees of rarity or frequency of the respiratory movements are, in general, ascertained as well by the eye as by the ear, but auscultation reveals, besides, the difference in the characters of sound.

When the inspirations are rare, the respiratory murmur is sometimes more feeble and sometimes more intense; as, for example, when the patient sighs deeply;—when they are frequent, it is generally stronger, sometimes more feeble, or presents, at the same time modifications in its nature, which shall be afterwards examined.

Pathological signification.—Acceleration or retardation in the respiratory movements have only a very secondary importance in the rigorous determination of the diagnosis. Their slowness, in the pathological state, is almost always influenced by some disease of the cerebro-spinal system, while their acceleration presents itself in too many thoracic and abdominal

affections to have, in itself, any precise semeiological value. It can only be said, in a general way, that a very frequent respiration probably indicates an extensive or serious lesion of the thoracic organs.

2. *Continuity.*

The vesicular murmur is, in the normal state, continuous, in both acts of respiration. In the morbid condition it is sometimes interrupted, constituting what is called abrupt respiration.

Characters.—This phenomena is chiefly observed in the inspiration, which appears to take place, at several intervals. It exists, sometimes, without alteration in the intensity and character,—sometimes with feebleness or harshness of the respiratory murmur. In some cases it is discovered every time that auscultation is made; and in others, it is heard only occasionally.

Physical cause.—The cause of abrupt respiration is sometimes evident, as when an intense pleurodynia, for example, arrests the dilatation of the thorax, which, being frequently checked, is not accomplished till after several efforts. In other cases, its mode of production is more difficult to understand. As it is generally observed in individuals affected with commencing phthisis, or who have presented, at some previous epoch, signs of pleurisy, it is probable, that it also depends upon the difficult and incomplete dilatation of the pulmonary cells, and upon the impediment to the free expansion of the lung, caused by adhesions.

Pathological signification.—When abrupt respiration is not artificial, that is to say, when it does not occur in an individual, who is not able to draw a breath;—when it does not depend on the irregular and incomplete play of the inspiratory powers, as in asthma or pleurodynia, tubercular affections may be suspected, which are so often accompanied by partial pleurisy at the summit of the chest; and this suspicion will approach to certainty, on the phenomenon being observed in the anterior and superior parts of the thorax, and coexisting with dulness on percussion and depression of its walls. It is found also in some cases of chronic pleurisy, which have terminated in adhesion.

3. *Duration.*

It is sometimes the absolute duration which is affected, without any change in the normal relation of the two acts of respiration; sometimes it is the relative duration of inspiration and expiration.

A. *Alterations in the absolute duration.*—When this duration is increased, the increase extends to both acts, but chiefly to the first, and constitutes *long respiration.* The respiratory murmur prevents its natural intensity, as is seen in certain cerebral affections; or it is louder, as in those cases, where there is supplementary respiration. In other circumstances, the intensity is diminished, and this feebleness becomes the principal alteration. (See *feeble respiration.*)

When the absolute duration is lessened, respiration is said to be short; in which state the respiratory murmur sometimes does not lose its normal force, as happens in some nervous affections; and sometimes it is increased, if a moral emotion, violent exertion, &c., or some morbid condition have had the effect of accelerating the respiratory movements. In other cases, respiration is at once short and feeble; and it is this latter character, on which the attention should be exclusively fixed.

B. *Alterations in the relative duration.*—The stethoscope detects some diseases of the chest, by changes in the relation, which naturally exist between the two periods of respiration. In certain cases, inspiration is longer, while expiration continues the same, or is shorter than usual; a variety, which is uncommon and of little value in forming the diagnosis. On the other hand, expiration is often longer, while inspiration continues normal or is shortened; and this is a variety, which it is important to study. It constitutes *prolonged expiration.*

Prolonged Expiration.

This phenomenon had not escaped the observation of Laennec, inasmuch as he has noticed the normal respiratory murmur,* and his book contains the precise indication furnished by expiration as a pathological sign: "In some cases," says he, "I have been much struck with the appearance of a phenomenon, which is most commonly produced, when a certain number of tubercles are desposited in the substance of the

*See Note S.

pulmonary parenchyma—I mean the expiratory murmur—I have heard it distinctly in individuals, who presented the different deducible signs of pneumonia, at the same time, that in them the sound was no where modified, and the vesicular murmur also appeared to continue unaltered. In proportion as the disease proceeded towards resolution, so did the expiratory murmur disappear, and no trace of it was perceptible, when the cure was once accomplished." The illustrious discoverer of auscultation had not, as we see, overlooked the existence of the expiratory murmur, nor its connection with the first stage of phthisis, but had only mentioned the fact in his immortal work, without developing it, as has been done by those coming after him. Among his successors, M. Andral was one of the first to notice the two periods of respiration, and the expiratory murmur in phthisis, (Clinique Medicale, 3d Edit. Vol. IV, p. 69.): "At the same time that the presence of a certain number of tubercles diminishes in that part, where they are deposited, the intensity of the sound produced by the expansion of the lungs, another phenomenon may take place, which is an unusually loud sound during the period of expiration. This is accompanied by a blowing much louder than that, which coincides with the movement of inspiration." An American physician, Dr. Jackson, proceeded further. He made the act of expiration his special study, and collected the greater part of the practical observations connected with its history; such as, its co-existence in phthisis with the pliancy and gentleness of the inspiratory murmur; its manifestation in cases, where the density of the pulmonary substance is augmented; the gradual progress of the bronchial character of the expiration extending to that of inspiration. These facts, laid before the Medical Society of Observation, by the author in 1833, were made generally known by M. Louis. Since 1835, we ourselves have taught them in our private lectures on auscultation, and they have become quite common among a certain number of individuals. Latterly, M. Fournet, availing himself of the discovery of his predecessors, studied the subject yet more deeply, and developed it still further.

Characters.—The sound of expiration is more or less distinct. In many circumstances it is at first scarcely perceptible, but gradually increasing in duration, approaches to that of inspiration, till it equals and finally surpasses it, so as to produce an inverse proportion to what these two acts bear to each other in their physiological condition. Its augment-

ing progress is the more observed, that it contrasts with the gradually decreasing inspiration, which, in the course of the disease, becomes shorter and shorter. Not unfrequently it appears before any other sign. Sometimes it is found alone, without any alteration in the tone of the respiratory murmur, but, most frequently, its characters are changed, becoming louder, harsher, and more bronchial, in proportion as its duration increases. Its favourite seat is the apex of the chest.

Differential diagnosis.—The noise produced in the mouth, pharynx, and nasal fossae, sometimes resembles that of prolonged expiration; but the one takes place at a distance, while the other is heard under the ear, and a little attention is sufficient for the appreciation of this difference in propinquity. The one varies according to the manner, in which the patient breathes, while the other is permanent, and continues for a long time with its own peculiar characters.

Physical cause.—Dr. Jackson had no difficulty in explaining *prolonged expiration:* "In the natural state," says he, (Mêm. de la Soc. Méd. d'Observ. Vol. I. p. 15), "when the pulmonary tissue retains its normal pliancy and permeability, the respiratory murmur is composed, at the same time of the sound, caused by the passage of air in the bronchia, and of that caused by its entrance into the pulmonary cells, and, as this latter predominates, it is the only one, which is heard. But whenever tubercular infiltration commences, the air cells becoming daily less numerous, the amount of their expansion diminishes, and, as the sound of the air traversing the bronchiæ continues the same, it predominates more and more every day, till it ends by being the only one which is heard. On the other hand, it is quite as easy to imagine that the bronchial expiration may precede the inspiration of the same character, when we consider the weakness of the expiratory murmur in the normal state; and since the first effect of induration of the pulmonary parenchyma is prolonged expiration, it follows, that the existence of induration is to be inferred from the presence of prolonged expiration, which may take place from the very commencement."

The manner, in which the prolonged sound of expiration is produced in such cases, appears to us very obscure. It seems difficult to determine, whether it depends, as Dr. Jackson asserts, on the fact of a phenomenon, which is nearly silent in the normal state, becoming perceptible under the influence of different conditions of density and vibrations: or

on an inequality in the elasticity of the pulmonary parenchyma (Fournet.)

Pathological signification.—Every affection where inspiration is shorter than in the normal state (pulmonary induration, pleurisy, &c.,) may proclaim itself independently of its own peculiar signs, by a change in the duration of expiration; but the phenomenon is then only accidental or quite secondary. It is only in emphysema, and above all in the first stage of phthisis, that prolonged expiration is observed permanently. The details given in other chapters (p. 46, 49) render it unnecessary to insist upon the diagnosis between those two affections. Let it suffice to keep in mind, that in emphysema the change in the expiratory sound affects chiefly its duration, and that it is often accompanied by a sibilous rhonchus, which is not present in tubercles, where harshness forms one of the chief characters of the phenomenon.

Conclusion: Semeiological value.—It may be said that prolonged expiration indicates only two affections, emphysema or tubercles in their crude state. In some cases it is the first or only stethoscopic sign of phthisis, and offers then a valuable means of diagnosis.

III. Alterations in Character.

Natural respiration may, under the influence of different physical lesions, lose its normal characters, and undergo modifications of its tone corresponding to the new condition of the organs. These changes have been designated *harsh*, *bronchial*, *cavernous*, *amphoric* respiration.

A. *Harsh Respiration.*

Synonyme.—Grating respiration.

Characters.—Harsh respiration presents different degrees of intensity, duration, and dryness. These alterations may affect both acts of respiration, or more particularly one of them; the expiration, which is besides prolonged, being the first to assume this character of harshness, which afterwards extends to inspiration. The phenomenon, observed at times over a considerable extent of the chest, occupies chiefly the summit of one or of both sides of the chest. It is in general permanent, and remains sometimes a considerable time without undergoing any remarkable modification; occasionally its transformations are rapid; the harshness, scarcely perceptible

at first, becomes more and more evident, and if it continue to augment, it insensibly approaches to the character of bronchial respiration. In other cases, when it reaches a certain degree, it is supplanted by crackling sounds or by râles. Sometimes it succeeds to the bronchial blowing, and follows a decreasing course till the respiration returns to its regular type.

Differential-diagnosis.—The distinction between harsh and peurile, bronchial or cavernous respiration is not always very evident. It is founded on the following considerations.—Peurile respiration being only, so to speak, an exaggeration of the normal condition, is unaccompanied by any other acoustic phenomenon, or alteration in the sonority of the chest (See p. 41, Puerile respiration); whereas the contrary is the case, in harsh respiration. Inversely, the simultaneous modifications of the respiratory murmur, and of the sonority of the chest, are much more marked in *bronchial* or *cavernous*, (See these words, pp. 60, 67) than in *harsh* respiration. It is easy to imagine, however, that to a certain degree it may be scarcely possible to distinguish between harsh and bronchial respiration, as the shades of difference are slight; but then the corresponding lesions are in more than one respect, identical.

Physical cause.—The organic conditions associated with the existence of *harsh* respiration, are thickening of the walls of the air-cells, induration of the pulmonary parenchyma, or more rarely, dryness of the mucous membrane of the bronchiæ.

Pathological signification.—Harshness is undoubtedly the most common of all the morbid modifications of the respiratory sounds. There are few affections of the respiratory organs which are not marked, at some period of their course, by this characteristic. Thus, respiration may become harsh, on the slightest change taking place in the interior of the bronchial tubes, as at the commencement of some cases of acute bronchitis, when the lesions are not sufficiently developed to cause continuous râles. It is harsh in pulmonary emphysema, with thickening of the walls of the dilated air-cells; in incipient phthisis, when the density of the pulmonary parenchyma has been augmented by deposition of crude tubercles or granulations; at the period of resolution of certain cases of pneumonia, in which the tissue has not quite recovered its pliancy; finally, in every case, where there is induration of the substance of the lung, (melanosis, chronic pneumonia, cancer, &c).

Analytical diagnosis.—The diseases, in which respiration is more or less harsh, are so numerous that the physician, in

making his diagnosis, should exclude, at first, the very rare affections, and turn his attention only to the more common, reserving to himself the subsequent correction of the opinion he has for the time formed. Should this harshness of the respiratory murmur be almost general, without any modification of the sonority of the chest, and be accompanied by no other phenomenon than a sonorous or mucous râle at intervals, it indicates the existence of slight bronchitis. Should it succeed bronchial blowing, or be mingled with returning crepitating râle, it announces the incomplete resolution of pneumonia. Should it be remarkable for its dryness; being most evident in the parts of the chest corresponding to the free margins of the lung, and coinciding with bulging of the chest and exaggerated sonority, it will depend upon pulmonary emphysema. Should it be accompanied by a sound of prolonged expiration; being limited to the summit of one or both sides of the chest, with resonance of the voice and obscure sound on percussion, crude tubercles may be diagnosed; and if dry or moist crackling subsequently supervene, softening of these tubercles has commenced.

Conclusion: Semeiological value.—Harsh respiration, continuing a certain time with a decided character of hardness, is an almost certain indication of phthisis in the first stage, or of pulmonary emphysema; if it exist with excessive sonority of the chest, it will be the latter; if with dulness, the former.

B. *Bronchial or Tubular Respiration.*

Synonymes.—Tubular blowing, bronchial blowing, blowing, blowing respiration. These different terms are synonymous, but the words *tubular* and *blowing*, express a more intense degree of the phenomenon.

Characters.—Bronchial respiration is remarkable at once for its increase in intensity and for its higher tone, and is very well imitated by the sound produced on breathing and blowing through the hand, closed so as to form a tube, or through a roll of paper, or through the stethoscope; the quicker and more strongly this is done, the more will the noise resemble that of the tubular blowing. When the bronchial respiration is less pronounced, it resembles more the prolonged and harsh sound produced by the passage of air through the trachea. It is perceived in both acts of respiration, and is sometimes more evident in the second, not unfrequently showing itself first in expiration. It has several degrees of intensity, and

presents, as we have seen, many intermediate degrees from simple harshness to true blowing. Its tone is no less variable, sometimes giving the impression of air passing through tubes with solid walls, and sometimes appearing to vibrate in flattened tubes.* Bronchial respiration may extend over every part of the chest, but affects chiefly the posterior and inferior regions. Its extent is variable. In one case it is more or less distant from the thoracic walls; in another it is so superficial, that the blowing may be said to be thrust into the ear of the observer. Moreover, the phenomenon is continuous, permanent, and not subject to intermittence.

Differential diagnosis.—Bronchial, when it is not well marked, cannot be distinguished from harsh respiration, (see p. 57). It presents a still stronger analogy with cavernous respiration, especially if the latter be produced in small pulmonary cavities; but cavernous respiration has generally a hollow character, which is not perceived in bronchial respiration, and is also distinguished by the circumstance of its being, much more frequently than the latter, accompanied by moist râles with large bubbles. The tubular blowing, when at its maximum, has a particular tone, which prevents us from confounding it with any other modification of the respiratory sounds.

Physical cause.—Bronchial respiration depends on several causes—1st. On silence of the vesicular murmur; 2d. On the rapidity, with which the air traverses the bronchiæ;† 3d. On an increased elasticity of the indurated pulmonary tissue, which becomes at the same time a better conductor of sound.‡ It also occasionally coincides with dilatation of the bronchiæ.

The blowing is more evident in proportion as the physical conditions already quoted are fulfilled. Thus, the more complete the silence of the vesicular murmur, the more accelerated the respiratory movements, the more dense the pulmonary parenchyma; finally, the more the walls of the bronchiæ are supported by a resisting tissue, and the better pronounced the bronchial respiration, the more truly blowing will it be. It will also be so much the stronger, if the pulmonary induration occupy a considerable extent,§ and will be heard the more distinctly, if the point of the origin be near the ear, and if no râle or sound take place in the neighbourhood. If, on the contrary, vesicular respiration persist, to a certain

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*See Note T. †See Note U. ‡See Note V. §See Note W.

degree, if the inspiratory movements be less energetic, if the induration of the parenchyma be less considerable, and extend over a smaller space, if the point of origin of the blowing be far from the ear, the phenomenon will, under these circumstances, be proportionally less perceptible. It may even happen, that bronchial respiration *exists without its being perceived*, whether on account of its distance, its imperfect transmission, or of its being masked by other concomitant sounds. In other cases, notwithstanding the existence of the requisite anatomical lesions, this phenomenon may not be distinctly produced, if any local obstacle impede the air in its progress to the bronchial tubes, or if it circulate too slowly through them.

Pathological signification.—Bronchial respiration is heard in cases of uniform dilatation of the bronchiæ, especially if there exist an increased density of the surrounding pulmonary tissue;—in cases of induration of the lung, whatever be its cause (cancer, melanosis, apoplexy, &c. and chiefly tubercles in their crude stage, and inflammation of the pulmonary parenchyma). It is also perceived, as an exception in some cases of pleurisy with effusion.

Analytical diagnosis.—If the tubular blowing exist without any marked dulness on percussion; if it continue for weeks, months, or years without fever, and without any serious influence on the general health, it indicates dilatation of the bronchiæ.

Bronchial respiration, when accompanied by dulness on percussion, reveals some pulmonary induration. In whatever part of the lung the phenomenon is observed, if it be limited and of slight intensity, continuing for a long time without any remarkable change, it is probable that the induration is connected with the existence of rare accidental products (melanosis cancer, &c.) If it commence suddenly in an individual laboring under some affection of the heart, and be accompanied by extreme oppression, expectoration of pure blood, and by subcrepitating râle at a circumscribed point, an apoplectic induration may be diagnosed. If there be bronchial respiration beneath the clavicle in a patient who has habitual cough, accompanied by emaciation, &c. the induration depends upon tubercles. If the bronchial blowing be well characterised, if it be more common at the base and at the posterior portion of the lung, if it have been preceded or accompanied by crepitating râle, and present itself with symptoms of an acute affection of the respiratory organs, pneu-

monia in its stage of hepatisation may be safely diagnosed. The degree of intensity of the blowing will indicate the amount of induration; its commencement will mark the passage from the state of engorgement to that of red hepatisation; its persistence along with serious febrile phenomena, the appearance of grey hepatisation; its diminution, the resolution of inflammation; its prolongation, the termination in chronic pneumonia; and the space over which it is heard, will announce the extent of the anatomical lesion. If pneumonia, instead of being lobar, be lobular, (a form which is so frequent in children), or if it be central, the bronchial respiration will be much less marked.

Some authors consider bronchial respiration as being also a sign of pleurisy with liquid effusion. This proposition, although in some respects true, becomes a serious error, when announced without reserve or explanation, and it is a subject of astonishment, that none of all the observers, who maintained it, has added to his assertion a corrective clause, which is indispensable. For ourselves, we should say that bronchial respiration can be heard in pleurisy, but that for the most part it is not heard: the tubular blowing is an exception to this disease, and an exception, moreover, so rare, that when it is heard, something else than a simple pleurisy should be suspected. This opinion, at which we have both arrived simultaneously, without any preconceived idea on the subject, is, we have no hesitation in affirming, the expression of the truth, and based upon a considerable number of facts carefully observed and considered. Let us stop for a moment to consider this important point of semeiology and we shall see that it is easy to account for the fact of bronchial respiration being rarely heard in pleurisy.

In fact, it is only observed in certain given circumstances. It exists sometimes at the commencement, when the fluid is still in small quantity, but only if the patient be made to breathe strongly, or if there be considerable dyspnœa, that is to say, if the air traverse the air-tubes with rapidity, and, consequently, with much noise. When the respiratory movements are neither great nor quick, and when the patient is allowed to breathe naturally, no blowing is heard, and the vesicular murmur is either weak or altogether absent. The effusion, it will be said, renders the cells impermeable; vesicular respiration is no longer possible; the air, therefore, vibrates only in the bronchiæ, and the respiration should, accordingly, be bronchial. We do not dispute the physical

fact itself, but the induction which is drawn from it: for, if the compression be great, the lung is at a distance from the ear, and, consequently, the phenomena is in a bad condition for its transmission. It is objected, on the other hand, that the fluid may be uniformly diffused over the surface of the organ, compressing it moderately and to a great extent, so as not to separate it far from the ear. But such mode of compression is only possible in particular circumstances, which prevent the liquid from obeying the laws of gravity, whether in those cases where the effusions are circumscribed posteriorly or latterly by false membranes, or in others, where partial adhesions fix the lungs to the diaphragm, and force the serum to ascend backwards, between the walls of the chest and the posterior part of the organ. Keeping those conditions out of view, where the lung is either sound or indurated; if it be sound, it will float; the fluid will rest accumulated at the posterior and inferior part of the chest; and it is evident that then nothing but silence of the respiratory murmur can ensue; if the parenchyma be indurated, it will sink, and then the bronchial blowing will depend upon the density of the pulmonary tissue. In the case of those chronic effusions, which fill the whole cavity of the pleura, the lung is undoubtedly submitted to a general compression; but, besides its considerable distance from the ear, another condition, namely, the slowness, with which the air arrives in the air-tubes after the cessation of the dyspnœa, prevents the respiration, which takes place in the bronchiæ, from being heard.

Allowing, in the meantime, that the bronchial blowing is perceived in some cases of pleurisy with effusion, it has characters, which distinguish it from the blowing of hepatisation. Thus, in pneumonia, it appears to take place in cylindrical tubes, and, as if under the ear of the auscultator; it may, besides, be heard in every point, where there is dulness on percussion, and is not subject to local changes. In pleurisy, on the contrary, it seems to be produced in flattened canals, and, as it were, in the distance, it is generally heard only from behind, at the roots of the bronchiæ, between the vertebral column and the internal margin of the scapula, although dulness may exist over a considerable surface; finally, it is sometimes susceptible of displacement by varying the posture of the patient.

The preceding considerations show, 1. That the pathognomonic sign of pleurisy, with effusion, is the silence of the respiratory murmur, and not the presence of bronchial respi-

ration; 2. That the blowing almost never exists except at the commencement of the attack, or in some particular cases and only in the neighbourhood of the roots of the air-tubes;, 3. That if it be perceived elsewhere, the pleurisy is not simple, but is complicated with pulmonary induration. If, in a case of acute pleurisy, the blowing be perceived distinctly, and but little distant from the ear, it may be concluded that pleuro-pneumonia exists; if, on the contrary, it supervene in chronic pleurisy, where the resolution is slow and difficult, it will announce a complication with pulmonary induration, which is very probably the effect of tubercles. Without further enlarging on the subject, it will be seen how important for prognosis and treatment is the knowledge of the fact, which, we hope, is placed beyond doubt.

Conclusion: Semeiological value.—Bronchial respiration is one of the most significant acoustic phenomena. It indicates, almost always, pulmonary induration; and of all the alterations which can increase the density of the lung, pneumonia and tubercles are beyond comparison the most common. Since all the conditions of blowing respiration are united in pneumonia, while several are absent in tubercular deposition, the tubular blowing is almost pathognomonic of hepatisation of the lung. It is present only as an exception, in pleurisy, and then it proclaims almost always pleurisy complicated with pneumonia or tubercles.*

C. *Cavernous Respiration.*

Synonymes.—Cavernous blowing, hollow respiration.

Characters.—Cavernous respiration resembles the sound produced by blowing into a hollow space, and is well imitated by a forcible expiration made with the mouth wide open into the hands, arranged so as to form a cavity. It takes place generally in inspiration and in expiration: is continuous, and more or less prolonged, and presents different degrees of intensity and tone.† Its favorite seat is the apex of the chest of one or both sides, and it is rarely heard at the base. Generally limited in extent, it is permanent, and if it disappear, it does so only at intervals, or is replaced by the cavernous râle.

Differential diagnosis.—Cavernous respiration, when well marked, has a particular tone, which characterises it; but

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*See Note X. †See Note Y.

sometimes harsh or bronchial* respiration has a considerable analogy to it, especially, when it presents itself near the bronchial roots. Nevertheless the latter is generally less hollow, and very seldom accompanied by the moist rhonchus with large bubbles, and never by the sound of the *cracked pot* (*pot fêlé*) on percussion. Blowing respiration, independently of its tone and higher key, is distinguished from cavernous blowing, by its rapidity, which contrasts with the habitual slowness of cavernous respiration.

Physical cause.—Cavernous respiration is produced by the arrival of air in abnormal cavities, formed by dilated bronchial tubes, assuming the form of large pouches, or increased in their caliber at the expense of the pulmonary tissue. It varies in intensity according to the quickness, with which the air penetrates the cavity, and it is more strongly marked in proportion to the greater size of that excavation, to its vicinity to the walls of the chest, to the density of the surrounding tissue, and to its ready communication with the air-tubes. It, therefore follows, that a cavern can exist without occasioning cavernous blowing, either permanently, if the cavity do not communicate with the air-tubes, or transiently, if that communication be momentarily suspended. The quantity of purulent matter contained in the cavern, and the disposition of the bronchiæ opening into it, will also affect the intensity of the phenomenon. It will be very well marked, if the cavity be quite empty. Supposing that the quantity of liquid is moderate, there will be cavernous respiration, if the mouth of the bronchiæ be above its level; but, if one bronchial tube be above and another below, the cavernous râle and respiration will both be heard at the same time. If the cavity be not considerable and quite full, the râle alone will be heard without any blowing.

Pathological signification.—Cavernous respiration indicates a pouch-like *dilatation* of a pretty large bronchia, or the existence of a cavern properly so called.

Analytical diagnostic.—Pouch-like dilatation of the bronchia is a lesion rarely met with, which is unaccompanied by any considerable dulness on percussion (with some exceptions) or by the *cracked pot* sound, or by the several local or general symptoms attending the existence of true caverns. As it may affect all the bronchial tubes indifferently, the blowing in this case has no seat of preference. Some pulmonary

*See Note Z.

excavations are of a different nature, and depend sometimes upon a breaking up of tubercles, at other times upon an abscess, the pus of which has been wholly or partially evacuated, or also, upon gangrene after the discharge of the slough. How, therefore, can it be decided, what is the alteration, of which the cavernous blowing is the index? This is done by considering the seat of the phenomenon, and the circumstances under which it has appeared. If it be perceived at the base, or near the middle of the chest, while the respiration continues normal at the apex, the idea of a tubercular cavern ought to be dismissed, and that of an abscess or gangrenous deposit entertained:—if it have supervened in the course of an acute affection, if the sputa, at first rust-colored, have become puriform, the phenomena may be caused by the formation of *abscess* subsequent upon pneumonia:—if after some days' illness, the breath and expectoration become very fœtid, the cavernous respiration is probably produced in a *gangrenous deposit*, if the blowing be heard at the apex of the lung, on one or both sides, and if the affection be chronic, a *tubercular cavern* may almost infallibly be diagnosed.*

There are yet some caverns of a different kind; for instance, those which succeed to the evacuation through the bronchiæ of a softened apoplectic deposit, of an acephalocystic cyst, or of a mass of melanotic, cancerous matter. &c.; but these cases are so rare, that the possibility of this occurrence need hardly be taken into account, when interpreting and judging of the value of cavernous respiration.

Conclusion: Semeiological value.—On account of the unfrequency of the pouch-like dilatations of the bronchiæ, and of pulmonary cavities subsequent upon an abscess, gangrene, &c., compared with the frequency of tubercles, it may be concluded that nine times out of ten, cavernous respiration will indicate a cavern resulting from the breaking up of tubercles.

D. *Amphoric Respiration.*

Synonymes.—Amphoric blowing, amphoric buzzing, metallic blowing.

Characters.—Amphoric respiration is a resonant sound of a metallic tone, which can be very well imitated by blowing into a jug three parts empty,† or into a glass bottle with a

*See Note 2 A. †See Note 2 B.

narrow neck. It supplants completely the vesicular murmur, and is more evident during the first, than during the second act of respiration. It is continuous and generally somewhat prolonged. Its intensity varies; its argentine tone may be more or less distinct; it is sometimes accompanied by a kind of metallic thrill. It is rarely met with at the summit or the base of the chest, but most commonly at its middle and lateral region, external to the mamma, or in a corresponding point behind. The surface over which it may be heard, is very variable, being sometimes limited to a small space, and sometimes occupying the whole of one side of the chest. In some cases it is permanent, in others it disappears and returns at intervals, or is only heard during deep inspirations. In its progress, amphoric respiration, though feeble when it commences, may, on the following days, increase in intensity and extent; but more frequently it reaches at once its maximum of intensity, and the space, over which it is first heard, diminishes by degrees from below upwards, till the phenomenon disappears altogether. It almost always coincides with *metallic tinkling.*

Differential diagnosis.—Amphoric respiration can be confounded only with *cavernous*, and the distinction between the two is not without difficulty, when the character of the former not being well marked, and that of the latter being strongly so, there is, so to speak, an alloy of the two phenomena. Nevertheless, in a very great majority of cases, the argentine tone, and especially its coincidence with metallic tinkling, will establish the difference. Moreover, the cavernous râle almost always accompanies cavernous, and almost never amphoric respiration; the maximum intensity of the former is generally at the apex of the chest, while that of the latter is in the middle or inferior region: finally, in the one case, percussion produces a dull sound, or that of a *cracked pot*, in the other tympanitic sonority.

Physical cause.—Amphoric respiration is connected with the existence of a large cavity, either in the substance of the lung, or formed by the pleura, and communicating with the bronchiæ by a narrow orifice. It seems to be produced by the vibrations of air passing through the aperture of this cavity.*

Pathological signifiication.—Amphoric blowing announces a large pulmonary cavity, or an effusion of gas into the pleura, with perforation of the lung.

*See Note 2 C.

Analytical diagnosis.—Amphoric respiration is heard in its greatest intensity, and its metallic tone is most stronly marked, in pneumo-thorax or in pneumo-hydro-thorax with perforation of the lung. It is chiefly perceptible at the middle of the chest, because perforations take place generally at the base of the upper, or at the apex of the lower pulmonary lobe; and it is most frequently confined to this region, because pneumo-thorax occurring for the most part in tubercular patients, the upper part of the lung has formed adhesions with the walls of the chest, by means of false membranes, before the ulceration of the parenchyma takes place, and because the introduction of air into the pleura is soon followed by an effusion of fluid, which fills the lower parts of this cavity. Sometimes, however, on account of the abscence of such adhesions, air is effused into the whole serous sac. Amphoric respiration is then heard throughout a great extent, and this circumstance, which is never met with in simple caverns, is one of the distinctive characters of pneumo-thorax. The progress of the phenomenon presents also, in this latter affection, modifications different from those in the case of large pulmonary cavities; being well marked at the commencement, and diminishing the following days, both in respect to its intensity and extent, according as the secretion of fluid increases. It even ceases, if the level of the fluid rise above the point of perforation; but it reappears on the return of the physical conditions necessaay for its production, if the patient expectorate enough of the matter secreted. It can also disappear momentarily, if the respiratory movements be very feeble, or if some accidental cause close the orifice of communication; and if this occlusion be complete it may cease altogether. When nothing but air is effused into the pleural cavity, amphoric respiration will alone be heard, but when the effusion is partly fluid and partly gaseous, it frequently coincides with metallic tinkling and Hippocratic fluctuation.

The nature of the pneumo-thorax will be elucidated by a comparison of the various phenomena preceding, accompanying, and following the amphoric respiration. If an individual, for a long time affected with cough, whose thorax presents, at the apex of one side, a dull sound on percussion, with altered respiratory murmur, be suddenly seized with violent pain in the chest, and great dyspnœa; if one side become at the same time prominent, and very sonorous on percussion, and if metallic blowing be heard, there can be no

doubt of a tubercular perforation. If the breath and expectoration of the patient be particularly fœtid, a perforation caused by gangrene may be diagnosed. Should amphoric respiration have been preceded by signs of intense pneumonia, with purulent sputa and local râles, the rupture on an abscess into the pleura may be reasonably suspected. If to signs of a pleuric effusion (complete dulness, silence of the respiratory murmur, &c.) have succeeded a combination of quite different phenomena (tympanitic sonority, amphoric respiration, &c.) immediately after an abundant vomiting of purulent serosity or pus, it may be concluded that pleurisy, with effusion, has first terminated by ulceration of the serous membrane, and that the fluid has found an exit through the bronchiæ by a pulmonary fistula. This termination is much more rare than perforation by gangrene or abscess, which, in their turn, are less common than tubercular fistulæ of the lungs. Should amphoric respiration succeed to signs of pulmonary emphysema, the idea may be entertained that it is the result of pneumo-thorax, caused by the rupture of some of the superficial cells; but this is really an exceptional case.

In regard to pulmonary excavations, the amphoric respiration connected with them, has also distinctive characters; and it should be premised, that as such caverns are rarely very extensive, the amphoric respiration is seldom well marked. In these cases, its seat of preference is the apex of the lung. It is more circumscribed than in pneumo-thorax, but increases in intensity and extent, as the cavern is enlarged by the progress of disorganization going on in the pulmonary tissue. It coincides almost always with cavernous râle, voice, and cough, but is not accompanied by metallic tinkling, or if so, it is very indistinct and transient. The chest, in the points corresponding to these stethoscopic signs, presents dulness on percussion, or the sound of a cracked pot, and is not unfrequently depressed, instead of being dilated as in pneumo-thorax.

Whether amphoric respiration take place in a tubercular cavern, or in a vast gangrenous deposit, the argentine tone is nearly equal. The tubercular caverns, however, are the most common of all; their favorite seat is at the apex of the lungs, while that of the other excavations is lower down; they follow an essentially chronic course, while the others follow an acute one: the order in the succession of the stethoscopic phenomena is quite different, and these differencies consist in the mode of manifestation of the metallic blowing.

More embarrassing cases may occur, as, for instance, when there exists at the same time pneumo-hydro-thorax with fistula, and a large pulmonary cavern. The diagnosis must then be formed according to the progress of the disease, according to the succession of the functional and physical phenomena (the sudden increase of dyspnœa in the course of phthisis, the substitution of tympanitic sonority for a dull or cracked pot sound, and of a mixture of cavernous respiration, and amphoric blowing for cavernous râle), finally, according to the assemblage of the signs common to both alterations. One of us has seen a case, in which a similar complication was discovered by the combination of the preceding circumstances. "A woman, age 23, having had a cough for six months previously, entered the hospital, 14th August 1835. Nothing was ascertained at first, beyond dulness of sound at the apex on both sides of the chest, and harsh respiration, somewhat bronchial, with exaggerated resonance of the voice. On the 10th Sept. gurgling under the clavicles, and in the supra-spinous fossæ, was observed. The patient was seized on the 5th with extreme oppression, when amphoric respiration was perceived in nearly the two superior thirds of the chest, and there was at the same time gurgling and very great sonority in the anterior and superior half of the right side. On the 7th the amphoric blowing was less pronounced, only observed at the end of respiration, and preceded by cavernous respiration: amphoric respiration was slightly heard on the left side, but much less distinctly than on the right. The following is the report of the autopsy. Right side prominent and very sonorous. The right pleura covered with false membranes, contains about ten ounces of a yellowish, purulent, flocculent fluid, with numerous bubbles on its surface. The lung, adherent at its apex and base, is much flattened, and pressed against the vertebral column: it presents at the level of the second intercostal space two perforations, both of which open into an excavation capable of containing an egg, and communicating in its turn with a cavern as large as the fist: the rest of the parenchyma is condensed and studded with crude or softened tubercles. The left side is every where dull on percussion: the lung presents at its summit a large cavern, and numerous tubercles in different stages."

Conclusion: Semeiological value.—Amphoric respiration when well characterised, indicates almost infallibly pneumothorax, with pulmonary fistula, and pneumo-hydro-thorax,

when it is accompanied by metallic tinkling. When not well pronounced, it may proclaim the same lesions, but also a large cavern, which is almost always of a tubercular nature.

IV.—Abnormal Sounds.

There are two descriptions of abnormal sounds, one occurs in the interior, viz: in the bronchiæ and pulmonary tissue, which is termed râle; the other is produced at the surface of the lung, and is termed the sound of friction (frottement.)

II. TABLE OF THE ABNORMAL SOUNDS OF RESPIRATION.

ABNORMAL SOUNDS.	1st. *Genus.* SOUNDS OF FRICTION.		*Pleuritic friction.*	
	2d. *Genus.* RALES.	1st. *Group.* Dry Râles.	*Sonorous râle.*	Sibilant. Snoring.
		2d. *Group.* Moist Râles.	A. *Crepitating râle.*	
			B. *Sub-crepitating râle.*	Sub-crepitating râle with fine bubbles.
				Sub-crepitating râle with moderately large bubbles.
				Sub-crepitating râle with large bubbles.
			C. *Cavernous râle.*	
		Appendix.	Crackling. Crumpling.	

FIRST GENUS: FRICTION SOUND.

Pleuritic Friction.

History and Synonyms.—Laennec did not overlook the nature of pleuritic friction, which has been so well examined by Reynaud; (*Journal Hebd. de Méd.* No. 65, p. 576): he recognised the phenomenon in a patient, who was laboring under pleuro-pneumonia, and who was shown to him by M. Honoré, although he did not give it its proper morbid signification, and described it by the name of, sound of ascending and descending friction.

Characters.—In the normal state, the two folds of the pleura perform, during respiration, an ascending and descending movement, in an inverse direction; they rub against one another, (as M. M. Andral, Piorry and Fournet have ascertained by experiment), but on account of the smoothness of the surfaces, without producing sound. When certain pathological conditions unite, a sound manifests itself, which constitutes pleuritic friction. Its characters are indicated by its very name; it resembles the friction of two hard substances, which glide slowly over one another. Apply the palm of the left hand to the ear, and rub slowly with the fleshy part of the fingers of the right hand, over the meto-carpo-phalangeal articulation, so as to cause a slight crackling dry sound, and you have nearly an intimation of the sound of friction. It coincides, most frequently, with the first act of respiration, seldom with the second, and sometimes with both: in certain cases it is only heard at the end of long inspirations. It is continued or intermittent. It is commonly abrupt, if it be more or less prolonged, and is, as it were, composed of several successive crackling sounds. It changes in harshness, tone, and intensity, so that it may be divided into soft friction or rustling (*frolement*), and hard friction or rasping (râclement); when it is very strong, it may be perceived by the application of the hand to the thorax: the patient may even sometimes feel it himself. It conveys always a very distinct sensation of a superficial sound. It occupies, chiefly, the central, lateral, or posterior region of the thorax, and very rarely the summit. It is most frequently perceived over a tolerably limited space, and occupies, at other times, a more extensive region, towards the base of the chest. Being generally an isolated phenomenon, it is only accompanied by a diminution in the respiratory murmur,

and in the expansion of the lung. Its average duration does not exceed a few days; as an exception, however, M. Andral has proved its existence during more than three successive months, in a young man, convalescent from considerable pleuritic effusion.

Differential diagnosis.—Pleuritic friction may be confounded with pulmonary crackling, and with moist râles. The analogy between the sound of crackling of the lung, and that of friction of the pleura is sometimes very great; the distinction is then established by the difference of situation, (the former of these sounds, having for its favorite seat, the superior region of the chest), and by the disparity of the concomitant stethoscopic phenomena: accordingly the sound of crackling has been produced by a gradual diminution, and by various alterations of the respiratory murmur; it most frequently commences with bronchophony, along with prolonged expiration, &c.; it is followed, after a lapse of time, more or less considerable, by cavernous râle, cavernous voice and cough, and, at length, by all the signs of softening of tubercles. Nothing similar to this occurs in pleuritic friction. The râles are easily distinguished by their moist character: the globular form of their bubbles contrasts with the dry irregular and abrupt sound of friction: the cough assists materially in the diagnosis: it modifies the râles, renders them more evident, or causes them to disappear after expectoration, whilst it produces no change in friction-sound. It is only in one case that the distinction is more difficult, viz. when pleuritic friction resembles a somewhat dry subcrepitating râle; this seems to depend on the softness of false membranes, on the extent and reticulated disposition of their surface.

Physical cause.—In order that gliding of the lungs over the internal surface of the walls of the thorax, may produce a sound during the movements of elevation and depression of the ribs, it is necessary that the folds of the pleuræ, or at least one of them, present asperities on their surface. These asperities depend almost always upon the presence of false membranes, deposited on the serous membrane, and the varieties of the sound of friction are explained by the disposition of the pseudo-membranes; if they be dry and hard, friction will be dry and harsh; if they be soft, it will also be soft; if they be extensive it will be perceived over a more considerable space. The degree of permeability of the pulmonary tissue, has likewise an influence upon friction, which

will be short, if pulmonary expansion be diminished, and prolonged, if it be more complete. May not also the pouches, filled with air, which we observe on the surface of the lung, in certain cases of emphysema, occasion a friction sound during the expansion of the chest?

Pathological signification.—Having announced the anatomical circumstances, under which the friction sound is produced, we have, in doing so, also pointed out the diseases which it indicates. It is, indeed, recognised in plurisy, in certain cases of tubercles, in the pleura, in some other organic alterations of that membrane, and, according to several authors, in some varieties of pulmonary emphysema.

Analytical diagnosis.—Those forms of emphysema, in which several pathologists have admitted the existence of friction sounds, are interlobular emphysema, which furrows the surface of the lung with sinuous protuberances; vesicular emphysema, with effusion of air bubbles, which elevate the pleura; and, finally, partial emphysema disposed in layers in relief on the surface of the organ. Although these layers render the free surface of the plura uneven, there seldom results from it a manifest sound of friction: and we have never heard it *very clearly*, although we have examined a vast number of persons afflicted with emphysema, or at least we have never found it decidedly connected with emphysema alone, independently of any other cause capable of producing it. M. Louis, in his very complete monograph (*Mém. de la Soc. méd. d'obs.* T. I. p. 160.) has taken no notice of it. Pleurititc crackling is less frequent in certain organic alterations of pleura, which are, besides of rare occurrence, such as cancerous masses, cysts, &c. The result does not hold good in regard to *tubercles*, which may occasion a clear sound of friction, if they be deposited under the two serous folds, and form at their surface resisting protuberances; or if they be disseminated throughout the thickness of the pseudo-membrane; or, also, if extensive adhesions do not prevent the lung from being displaced during the dilatation of the thorax.

In simple *pleurisy* the friction sound is only produced under two circumstances: 1st. At the commencement, when the folds of the serous membrane are covered with albuminous exudation, and when the liquid effusion is not yet formed, or is not abundant enough to separate them from one another; but as the effusion is commonly quick in forming, these conditions of friction continue but for a short time; moreover, as the patients, especially those in hospitals, do not present them-

selves to our observation until some days after the commencement of the disease, the opportunity of hearing the sound offers itself only in the case, when the inflammation of the pleura is developed in the course of a pre-existing affection; 2d. Towards the termination of pleurisy, when the diminution of the liquid enables the folds of the pleura to come again in contact, when these are covered by pseudo-membranes, and when previous adhesions do not oppose their friction. When crackling appears at this second period, it offers a favorable prognostic, pointing out, as it does, the first efforts that are made to absorb the effused liquid.

The sound of friction is likewise, although rarely, perceived in cases of pneumonia, where inflammation affecting the surface of the lung, is accompanied by a pseudo-membranous secretion on the corresponding portion of the pleura.

Conclusion: Semeiological value.—Pleuritic friction indicates most frequently pleurisy in the progress of cure. If it were exclusively heard at the summit of the chest, we would have reason to suspect tubercular pleurisy.

SECOND GENUS: RALES.

Definition and division.—The name of *râle* is generally given to a sound, which is produced during the last moments of life, by the passage of a current of air through the mucous accumulated in the larynx, the trachea, or the large bronchial tubes. Laennec (whose example we shall follow) has used this word in a more extensive acceptation; he has distinguished by this term, "all abnormal sounds which the current of air may produce during the respiratory act, either by traversing liquids, which are present in the bronchiæ or the pulmonary tissue, or owing to a partial stricture in the air passages.

He has distinguished five different species: 1st. The moist crepitating râle, or crepitation. 3d. Mucous râle or gurgling. 3d. Dry sonorious râle or snoring. 4th. Dry sibilant râle or whistling. 5th. Dry sibilant râle with large bubbles, or crackling.

This classification is far from being irreproachable, and pathologists have not failed to introduce changes, which usage has consecrated. Accordingly two distinct râles have been made, of *mucous* râle or *gurgling:* the former, which has retained the name of *mucous*, designates only the moist rhonchus, which is produced in the ramifications of the bronchiæ; by the other, viz. *gurgling*, we understand almost

always the râle with large bubbles, which occurs in dilated bronchial branches, or in pulmonary caverns; it has received the synonym of *cavernous*, and both terms are used promiscuously. This change in the terms has the advantage of establishing an exact distinction between two phenomena, of which the character, the anatomical seat, and the morbid signification are, during the greater part of the respiratory act, very dissimilar, and which it is of importance not to confound. Laennec had assumed two râles, *snoring* and *whistling;* it is much more simple to regard them merely as two varieties of the same râle, since both are so frequently mingled, and are connected with analagous physical conditions. In regard to the *dry crepitating* râle *with large bubbles*, which, according to Laennec, would be a sign of interlobular emphysema, those observers, who have devoted themselves to auscultation, have not thought it distinct enough to deserve a special name, and they have eradicated it from the number of abnormal sounds.

M. Andral has proposed a division of râles according to their anatomical seat; he distinguishes them into vesicular, bronchial, and cavernous râles.—Vesicular râle is formed in the cells of the lungs; bronchial râles in the bronchiæ, and they are sometimes dry (sibilant or snoring), sometimes moist (mucous); cavernous râle borrows its name from the pulmonary cavities, where it is produced.

This classification, based on anatomy, would, as more scientific, be preferable to that, which is founded upon physical sensations received by the ear; but it is not free from objections; it is exposed to the inconvenience of deciding, before hand, a question as to its anatomical seat, which is sometimes doubtful. It has not the advantage, which is a very valuable one, and especially to beginners, of conveying to the mind by its own appropriate term, a clear and comprehensive idea of the stethoscopic phenomena.

Moreover, as this principle has not been applied to all the classes of acoustic signs, it would have the disadvantage, by associating new names borrowed from anatomy, with words representing physical sensations, of destroying the harmony and unity, which it is so desirable to introduce into a general classification. For our division we have preferred the basis, which Laennec has chosen for his own, being persuaded that the study of auscultation becomes thus more simple and easy; but while building on the precepts of the master, we have, notwithsanding, for practical purposes, introduced various

modifications. Thus we have made of the *sibilant* and *snoring* râle, two varieties of one and the same *sonorous* râle. We have thought it proper to change the name of *mucous* râle, as this term was often incorrectly used, and gave a false idea of liquids contained in the bronchiæ, by leading us into the false belief, that it is always caused by the presence of mucus, when it is often pure blood, sanguinolent serosity, or pus. We have substituted for it the word *sub-crepitating*, of which we have formed three varieties according to the size of the bubbles. 1st. The fine sub-crepitating râle. 2d. The intermediate sub-crepitating. 3d. The sub-crepitating râle, with large bubbles or gurgling. Adopting the signification, which has been given to the *cavernous* râle by almost all the successors of Laennec, we have taken it in its most general acceptation, as a sign of any cavity whatever, formed in the tissue of the lung. If from the size of the bubbles, *cavernous* râle become confounded with *sub-crepitating râle with large bubbles* or *gurgling*, it is almost constantly distinguished from it, by the concomitance of cavernous blowing, (souffle): and the combination of these two phenomena, being the most certain indication of caverns in the lung, it seemed to us to deserve a particular name.

In short, we shall give the name of rale to abnormal sounds, which being developed in the air passages, mingle with the respiratory murmur, and obscure or supplant it entirely; we shall divide them into two groups; one is called *dry*, because it consists only of variable *sounds*, and the other *moist*, because it is characterised by *bubbles*. In the presence of patients, we ought to use, in preference to the word *râle*, which might frighten them, the Latin expression *rhonchus*.*

FIRST GROUP.—DRY RALES.

Sonorous Râle.

Synonyme.—The *dry sonorous* or *bronchial* râle, comprehends, as we have already said, two principal varieties, designated by the terms, *acute sonorous*, or *sibilant* râle, and *deep sonorous* or *snoring*.

Characters.—The sibilant rale is a musical whistle, of a tone more or less acute, which accompanies or disguises the respiratory murmur. Sometimes it is very short, and

*See Note 2 D.

analogus to the clacking sound of a small valve: sometimes it is prolonged, and resembles the cooing of a turtle dove, or the sound of the wind whistling through the crevices of a door. The *snoring* rale is characterised by a deeper musical sound, similar to the snoring of a person asleep, or rather to the sound, which a base cord yields to the touch of the finger.

The *sibilant* rale is more common than the *snoring* rale, they are often combined, and sometimes alternate or supplant each other.

Sonorous rale is heard either in inspiration or in expiration, or in both, and is short or prolonged in direct proportion to the duration of those acts. It is of variable intensity, and sometimes loud enough to be heard at a distance. When it is loud, it communicates to the hand, when applied to the chest, a particular trembling, which indicates that the air has put the bronchial tubes into vibration, as it rushes through them during inspiration, and as it is expelled from them during expiration. Being rarely circumscribed, it is commonly perceived on either side of the chest, and resounds from the summit to the base, and as it does not accompany all respiratory movements, it may show itself at the first inspiration, disappear at the second, and reappear afterwards. It often coincides or alternates with the *sub-crepitating râle* (mucus of Laennec), which is almost always entirely substituted for it.

Differential diagnosis.—It is very easy to distinguish the sonorous râle from other species of rhonchus: if it occur alone, it has indeed a very particular musical tone, and when once heard, it is easily recognised. We might, however, confound it with *guttural snoring*, which accompanies certain cases of dyspnœa, but this latter sound is entirely produced in the nasal sinuses and the back part of the mouth, and the simple application of the ear or stethoscope convinces us, that it has nothing in common with bronchial râle, and that it occupies altogether a different situation. In some cases of stricture of the mitral or aortic valves, the *friction of the blood* causes a musical sound, which resembles in some degree the short whistling of *sonorous* rale; but with the least attention this error will soon vanish. To isolate by auscultation respiratory sounds from the sounds of the central organ of circulation, and to convince ourselves that the musical whistle coincides in the first place with the movements of the systole or diastole, and in the second, with those of respiration, is all that is necessary. The sounds, which take place in the stomach, resemble very seldom one of the two modi-

fications of sonorous rale, the clacking of a valve; it is enough to point out this fact, for the purpose of preventing mistake.

Physical cause.—The mechanism displayed in the production of sonorous rale is difficult to be determined: it has been compared to that of musical sounds in the organ, where the air, intercepted by the reed in its passage through the pipes, produces variable tones. According to Laennec, "the musical nature of *snoring* râle, would induce us to believe that this is owing to some change in the form of the canals, which the air traverses in the lungs." Acute *whistling* appeared to him to depend "on a local stricture, caused by swelling of the internal membrane of a bronchial branch of small, or moderate caliber." Though it seems evident that sonorous râle depends on vibrations in the bronchiæ, as the air traverses these canals, we should only infer, with the utmost caution, the existence of a local swelling of the mucous membrane, as the cause of these vibrations. The presence of more or less viscid mucous, which, by forming as it were vibrating folds or cords, modifies the current of air, is a more positive fact. It is not easy to determine precisely, whether the difference of sounds can be explained by the various lengths and diameter of the air tubes, or by the different number of vibrations produced in a given time.

Pathological signification.—The *sonorous* râle may be found in a great number of diseases, which exist in the interior of the bronchiæ, or which have their seat on the outside of these tubes in the tissue of the lung; these are chiefly acute or chronic inflammation of the bronchiæ, when the morbid secretion is not very abundant or not yet established; tumors, situated on the course of these canals, and pulmonary emphysema. These different pathological states have one common element, viz: a momentary or permanent stricture in one or other point of the air-passages, and from this results a phenomenon, which is uniform as to its foundation, but presenting varieties in connection with these different diseases.

Analytical diagnosis.—In acute bronchitis, the râle shows itself most frequently under those principal characters, which we have mentioned. It is more prolonged in inspiration, which is of its normal duration, than in expiration. From being at first very musical, it diminishes gradually in intensity, and the bronchial mucous membrane becoming more and more moistened with liquid, it finally mingles with sub-crepitating rhonchus, by which it is at length entirely supplanted. It resounds almost always over all points of the chest, being

local only in partial bronchitis. It follows pretty regularly the progress of inflammation, the phases of which it marks, up to a certain point, by its presence, its diminution, and its complete disappearance or transformation into the moist râle. It occurs much more rarely in chronic bronchitis than the sub-crepitating rale: it only appears at intervals, as, *e. g.* when an acute attack is superadded to chronic inflammation, and even then it coincides with moist rale. Sometimes we have sonorous rale variously modulated, in bronchitis complicated with caverns: it is then generally distinguished by its occupying the summit of the chest, by its predominance in this point, and, when it is about to cease, by the manifestation of the signs of pulmonary excavation.

The compression of the bronchiæ by tumors very rarely occasions sonorous rale, which would be, besides, local and not general, as happens in most cases of emphysema and bronchitis. Laennec having sometimes recognised sonorous rale in *pneumonia*, had attributed it to the compression of the bronchial tubes by engorged pulmonary tissue: has he not deceived himself, in the interpretation of this fact, which may be better explained by the coincidence of bronchial inflammation? In the same manner, if snoring rale be manifested in children pretty frequently at the commencement of pneumonia, we should not attribute it to engorgment of the organ, but to inflammation of the bronchiæ, which soon propagates itself in continuous progress to the pulmonary cells.

Sonorous rale shows itself with the greatest intensity in *emphysema* of the lung. It is remarkable for its various tones, and chiefly for the predominance of whistling. In greatly developed emphysema, it is, so to speak, continuous, and its uninterrupted emission is scarcely separated by intervals of rest, which occur in the normal state, between each respiratory movement. It often coincides with sub-crepitating rhonchus, and almost always with an incomplete vesicular expansion. Although sonorous rale is very frequent in emphysema, we ought not to think that it is necessarily connected with this affection, and that it is invariably the effect of an altered condition of the pulmonary cells: thus it is of rare occurrence in summer, comparatively with the number of individuals affected with emphysema, but far more common in winter, and in damp weather, on account of the extremely frequent occurrence of bronchitis: this rale is therefore not the herald of emphysema alone; catarrh has a great share in the production of the phenomenon. In certain cases, also,

may not a nervous element contribute to the manifestation of the rale: do we not, in some asthmatic persons, find that the musical sounds only appear by fits, for example, under the influence of a general emotion, and disappear during the interval of the attacks?

Acute inflammation of the bronchiæ is so frequent in comparison with other diseases, where sonorous rale may be perceived, that we may be almost certain of its existence, if that particular sound become manifest; the only exception is emphysema, which, being a tolerably common affection, ought to be considered by the physician along with inflammation; however, as we have just seen that musical sounds, which are so frequently heard in emphysema, are almost always influenced by concomitant catarrh, its pathological signification is, after all, nearly the same, viz: an alteration of the mucous membrane of the bronchiæ, with inflammatory swelling and discharge of mucous; it is only farther to be decided, whether catarrh be idiopathic, or symptomatic of emphysema, and the other symptoms render the distinction generally very easy. But our diagnosis ought to go farther. After having determined the existence of bronchitis, we ought, not content with this first survey, to convince ourselves that sonorous rale does not conceal another stethoscopic phenomenon. Suppose, for example, that a severe attack of acute bronchitis is grafted on an inconsiderable pleuritic effusion, the sonorous rale being a positive sign, will, undoubtedly, disguise the absence of vesicular murmur, being a negative sign, and if, in this case, we confine ourselves to the appreciation of the louder sound, we would confound a much more serious disease with a trifling affection, and the diagnosis, because incomplete, would be erroneous. In like manner, in catarrh, which accompanies phthisis, pneumonia, &c., we ought not to consider our examination at an end after having recognised the noisy rale of bronchitis; we should continue our investigation, recollecting that the acoustic phenomenon is but one element in the determination of the disease.

Conclusion.—Semeiological value. On account of the frequency of bronchial catarrh, and the comparative rarity of other morbid conditions, where snoring or whistling may manifest themselves, the *sonorous râle* is of very great value; it indicates, almost to a certainty, an inflammatory or catarrhal state of the bronchiæ, and one single inspiration is sufficient to establish our diagnosis.

SECOND GROUP.—MOIST RALES.

A. *Crepitating Râle.*

Synonyme.—Vesicular râle.

Characters.—This râle conveys to the ear the sensation of fine and rapid crepitation, of which physicians have attempted to convey an idea, by several comparisons. Laennec says it resembles the sound produced by salt decrepitating under a gentle heat in a basin, or the sound, which is caused by blowing into a dry bladder, or, (still better,) to that heard on compressing the tissue of a healthy lung filled with air. Dance compares it to crepitation caused by throwing a pinch of uniformly pulverised salt into the fire. The friction of the hair rubbed between the fingers, or the sound accompanying the expansion of a moist sponge, the moment we cease to compress it, gives likewise a very exact idea of crepitating râle. This rhonchus is perceived in inspiration alone. Its bubbles are very small, of equal size, somewhat dry, and occasionally moist. They are commonly very numerous, and we might probably be able to count several hundreds under the area of the stethoscope: they form, as it were, a species of *crackers*, which continue during the whole first act of respiration; the number of bubbles is generally considerable, and the râle is only heard at the close of inspiration. One of its characters, which is very valuable in diagnosis, is its continuance: it commonly persists even after expectoration; at other times, (especially at the termination of the disease), it occurs, again only in the two or three first inspirations, and after a deep sigh, or an energetic inspiration, which follows coughing and disappears afterwards. Its favorite seat is the posterior and inferior portion of the chest, on one side only. At one time it exhibits itself single, at another it is accompanied by tubular blowing; in other cases it is mingled with bronchial râle.

Differential diagnosis.—If *crepitating râle* be well characterised it is easy to distinguish it from other kinds of moist rhonchus: its bubbles are very small, those of *sub-crepitating râle* (*mucous râle* of Laennec) are of moderate size, those of *cavernous râle* very large; they are quick in forming, whilst those of sub-crepitating râle, and, more especially, those of cavernous râle, are slow in doing so; they are exclusively perceived in inspiration, those of sub-crepitating and cavernous râle, may accompany inspiration as well as expiration; and, finally, it

occupies most frequently the base of the lung, and one side only, whilst sub-crepitating râle occurs almost always at the base of both lungs, and cavernous râle chiefly on the summit. One râle only may sometimes be confounded with the ordinary crepitating râle of pneumonia, this is the *fine sub-crepitating* râle, which manifests itself in acute capillary bronchitis; the near identity of their anatomical seat, (bronchial terminations on one side and pulmonary cells on the other) accounts for this close resemblance between the two species of râles; but if the râle of pneumonia be perceived on both sides of the chest, when there exists double pneumonia, we must consider it as *an exception*, whilst the existence of rale in both sides is *according to rule*, in capillary catarrh; if in this latter affection the bubbles be localized, we ought to suspect, that the inflammation has extended to the parenchyma. We should, besides, have recourse to other signs in order to establish with certainty the differential diagnosis.

Physical cause.—We generally admit that the crepitating rale is produced by a current of air passing through liquids contained in the pulmonary cells. Indeed, if we appeal to the ear, it seems that the cells contain matter, which forms no obstacle to the approach of the elastic fluid. Several characters of crepitating rale might tend to prove, that its anatomical seat is truly the pulmonary vesicle. The bubbles are like the cells, *very small, numerous, and of equal size.* Dance has justly remarked, that their very form seems to be the exact representation of their cells, and that the nature of the sound indicated the termination of the bronchiæ at their last divisions by vesicular dilatation. In persons advanced in age the bubbles are larger, because the cells of the lung are increased in consequence of the absorption of the intercellular tissue:* amongst children, on the contrary, with whom the vesicles of the parenchyma are very small, the bubbles appear to be of extreme fineness.

Pathological signification.—We hear crepitating râle in *pneumonia*, in certain forms of *pulmonary congestion*, in *œdema*, and *apoplexy of the lung.*

Analytical diagnosis.—Crepitating rale is produced in *pneumonia* with its characters most developed; it makes its appearance at the two periods of engorgement, viz: at the commencement and at the moment of its resolution, (returning crepitating rale). It is absent at the intermediate

*See Note 2 E.

period of hepatisation, where it is supplanted by bronchial blowing; towards the end it is often transformed into subcrepitating rale by the mixture of larger and moister bubbles. It is almost always perceived on one side exclusively, because double pneumonia is of rare occurrence, at least in adults: it is more common at the base of the lung, because pneumonia at the base is much more frequent, than that of the summit. In *active pulmonary congestion*, crepitating rale is occasionally met with, but its bubbles are most frequently larger, moister, viscid and nearly continuous, in which case it would rather deserve the name of subcrepitating. The same takes place in passive pulmonary congestion, which occurs without inflammation in enfeebled individuals.

Add to this, that the passive engorgement occupies the slanting portion of the lung, and that the rhonchus follows, in regard to its seat, the same physical law, and that it is remarkable for its continuance, on account of the long duration of the disease. Moreover, whether congestion be active or passive, the rale is neither accompanied nor followed by bronchial blowing, unless regular hepatisation of the lung be superadded. Several particular characters distinguish the crepitating rale of œdema, as well as that of pulmonary apoplexy: if the bubbles be very moist, and finer, if the rale persist a very long time without fever, and, above all, if there be a coincidence of more or less general dropsy, our diagnosis ought to establish œdema of the lung. If the rale occupy one or more circumscribed points of the chest, if at the end of several days it be not supplanted by bronchial blowing, or if this blowing, like bronchophony and condensation, be not very distinct; again, if the signs of pulmonary affection have appeared in the course of disease of the heart; and, above all, if the patient have been affected with expectoration of pure blood, we would recognise by this combination of phenomena, pulmonary apoplexy. We have crepitating rhonchus, if the blood effused into the vesicles remain fluid, and sub-crepitating rale if it enter the bronchial tubes; there would be no rale whatever if it were effused into the inter-cellular tissue, or if it were condensed in the vesicles.

Conclusion.—Semeiological value. On account of the extremely frequent occurrence of inflammation of the lung, contrasted with the comparative rarity of œdema and apoplexy, crepitating rale, especially when its characters are well developed, is a sign, almost pathognomonic, of pneumonia at the period of congestion. Crepitating rale does more than

merely point out the existence of pneumonia: by the point of the lung, which it occupies, it sometimes indicates the nature of the inflammation; if, for example, it have been developed at the circumference of tubercles. In reality, we have observed this inflammation of the superior lobe of the lung attacks the posterior half much more frequently and more actively than the anterior half; we have, in a similar way, ascertained as a consequence of this law of pathology, that the physical signs of superficial pneumonia, commence almost always behind, and that they generally continue to be manifested with greater distinctness at the posterior portion, when the inflammation has encroached upon the anterior one. We may infer from this fact a fixed principle in auscultation, of the first importance to diagnosis, viz: if crepitating rale be heard at the summit of the chest, exclusively in front, with coincidence of symptoms of fever, we should suspect tubercular pneumonia.

B. *Sub-crepitating Râle.*

Synonyms.—Mucous râle, moist bronchial râle.

Characters.—Sub-crepitating rale has been justly compared to the noise caused by blowing with a reed into soapy water; and in the same manner as this noise varies according to the diameter of the reed, the density of the liquid, and the force of blowing, the air presents in regard to the quantity and size of the bubbles, differences, which have induced us to esablish three varieties: it resembles sometimes crepitating rale in the number and fineness of its bubbles, and in the circumstance, that it accompanies chiefly inspiration (fine sub-crepitating rale); these latter are sometimes larger, less numerous, less equal, and are less exclusively perceived in the first act of respiration (intermediate sub-crepitating rale). Sometimes again they are large, rare, very unequal, and constitute a regular gurgling, which is perceived either alone, or along with inspiration and expiration (sub-crepitating rale with large bubbles). The rale presents, besides these characters, various modifications of tone, as if it were produced in liquids of a different density and viscidity: in one place the bubbles are clear and distinctly separated, in another, they are, if we may use the expression, coherent, and seem to discharge themselves the one into the other, so as to form an almost

*See Note 2 F.

continuous sound.* The intensity of the rale is generally in a direct ratio with the quantity of liquid contained in the air passages, and with the respiratory power. It is permanent, and occurs in every respiratory movement, or it may also disappear entirely, being besides modified by the cough and expectoration. It occupies a variable surface, and its favorite seat are the inferior and posterior portions of the chest on both sides. It coincides frequently with sonorous rale.

Differential diagnosis.—It is sometimes very difficult to distinguish sub-crepitating râle from other moist râles. If we consider, that the conditions of their production are nearly identical, that their physical cause is the same, and that they differ only in their anatomical situation, we may easily understand this resemblance. *Sub-crepitating râle* being placed between the two moist râles, one of which occurs in the vesicles, the other in the excavations of the lung, *is*, so to speak, *in contact* with the two râles found at its extremities, and borrows from them some of their characters; when accompanied by small bubbles it becomes confounded with the *crepitating* râle,—if by large bubbles, with the *cavernous.** One of the conditions, which modifies a râle, is the nature of of the situation where it is produced; there is, however, such a small difference in the capacity of the last bronchial ramifications and the pulmonary cells, that the various shades of rhonchus, that occur in the one or the other, can hardly be distinguished by the most practised ear. The same remark refers to the small excavations, the dimensions of which do not exceed that of the bronchial tube, and we may then understand how impossible it is sometimes to decide, merely from the size of the bubbles, whether the sound perceived, belong to cavernous rale with large bubbles.

Let us, however, try to establish a differential diagnosis, by by the most prominent characters of the various rales, apart from the size of the bubbles. The fine sub-crepitating rale is distinguished from the crepitating, by its being heard in inspiration and expiration, by its occupying a larger surface, and being more generalized, and, finally, by its not being accompanied nor followed by bronchial blowing. The sub-crepitating rale with large bubbles, differs from cavernous rale, by the latter coinciding almost always with cavernous respiration, cough, and voice.—Intermediate sub-crepitating rale can sometimes scarcely be distinguished from cavernous

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*See note 2 G.

rale with small bubbles, occurring in the small caverns, or from crepitating rale with moderately large bubbles, which is produced, especially in old people, in some cases of pneumonia or œdema: it is then the consideration of the seat of the rale, assisted by other stethoscopic signs, which ought to solve the difficulty.

Sometimes the diagnosis is impossible, unless we have recourse to other methods of exploration, because the different rales become confounded, in consequence of complex morbid conditions. Thus we may hear, on the same side of the chest, cavernous, crepitating, and sub-crepitating rale, if the same lung be excavated by caverns, some of which are large and others small, if inflammatory engorgement be developed around the circumference of tubercles, or if the bronchiæ, which enter the caverns be filled with mucus. In a case of hemoptysis, where the blood is furnished by a cavern, and fills up the bronchiæ, the ear may likewise perceive, at the same time, almost all species and varieties of rales: cavernous, sibilant or snoring, and fine, intermediate, or coarse sub-crepitating rale, according as the bronchial trunks, branches, or small ramifications, are obstructed by more or less liquid.

Physical cause.—The sub-crepitating rale is produced by a current of air through liquids, (blood, mucus or pus), contained in sufficient quantity in the bronchiæ, or in the small caverns. This fact has been directly proved by M. Piorry (*Traité de Diagnostic*, T. I. p. 466): he injected water into the lungs, and then distended them with air; when there was but little liquid present, the insufflation occasioned sonorous or sub-crepitating rale: when, however, there was more liquid, sub-crepitating and crepitating rhonchus, with moister bubbles was the result.

Pathological signification.—The sub-crepitating rale may be heard in a considerable number of diseases, such as the second stage of inflammation of the bronchial mucous membrane, the different species of catarrh, hemoptysis, dilatation of the bronchiæ with increased secretion, certain forms of congestion and pulmonary apoplexy, and phthisis, at the commencement of the breaking up of the tubercles.

Analytical diagnosis.—We have seen, (p. 63), that sonorous rale is heard in the first stage of bronchitis; in proportion as the bronchial secretion becomes established and more abundant, some bubbles of the sub-crepitating rale are superadded. Still later, moist rale predominates, and at last is the only one

heard. At the same time it becomes localized at the inferior and posterior portion of the two lungs. In some circumstances it may certainly spread higher up, and propagate to the superior and anterior portions of the organ (general bronchitis); but even in this latter case, its chief characteristic will be that of being more developed in the subscapular regions.

We ought, however, to observe the greatest caution in concluding, from the circumstances of its situation, that the inflammation affects, almost exclusively, the bronchiæ at the base of the lung. Certainly bronchitis of the base is, on account of the tendency of the inflammation to attack the slanting portions, more common than that on the summit, (we speak here of inflammation developed under the influence of a general cause, and not of bronchitis which is partial, from a local cause); but there are also several anatomical reasons, which explain the frequency and continuance of sub-crepitating rale at the lower and back part of the chest; the bronchiæ are more numerous at the base than at the summit, and there the danger of inflammation is consequently greater; they are longer, and the secreted fluids are detained for a more considerable time; finally, their direction is different, and such is the disposition of the tubes, that those of the superior portions are sooner relieved by expectoration, whereas those of the inferior portions, empty themselves with much more difficulty.

In a word, the size of the bubbles indicates the situation of bronchitis in the various sections of the air passages; the intermediate sub-crepitating, announces inflammation of moderately large ramifications; fine sub-crepitating rale, those of the last sub-divisions of the bronchiæ (capillary bronchitis); the sub-crepitating rale with large bubbles or gurgling, inflammation of those branches, the caliber of which is more considerable, (dilatation of the bronchiæ with increased secretion). It is sometimes possible, that the rale may be absent, if the inflammation exist in the large bronchiæ, and if the air traverse them without forming bubbles with the minute quantity of fluid which cover their walls. In *chronic bronchitis*, and *bronchorrhea*, the rale preserves characters similar to those we have now traced; but the concomitant local or general symptoms vary, and mark the species of inflammation. We have just seen, that in affections of the bronchial mucous membrane, sub-crepitating rale occupies solely the base of the chest, or that, if it occupy at once the inferior portions and

more or less elevated points, it is always more manifest in the former. It is, nevertheless, not very uncommon to discover sub-crepitating râle at the summit of one or both lungs. Shall we then consider it as superficial *bronchitis?* Undoubtedly not. There is something in this *local bronchitis*, which is not included under the ordinary rule; in order that inflammation may thus be confined to the summit, a cause must there exist, which excites it, a species of inflammatory stimulus, which provokes it, and this cause is the presence of tubercles; but if local bronchitis coexist with tubercles, catarrh is nothing else than a secondary affection, and phthisis constitutes the whole disease. But there is something else implied: when sub-crepitating râle shows itself at the summit of the chest, it depends most commonly, not on the mere presence of mucous in the bronchiæ; there exist already small pulmonary excavations, in which softened tuberculous matter is agitated by the elastic fluid.

In the same manner as the râle may ascend to the superior portion in widely spread bronchitis, so it may, on the other hand, occur that the rhonchus is perceived on both sides, (in the cases, of which we speak,) from the summit to the base of the thorax; but, while in the former case the maximum intensity of the râle is in the sub-scapular regions, its maximum is here in the sub-clavicular or supra and sub-spinous regions. These practical considerations are sufficient to show the immense importance of examining the *seat* of sub-crepitating râle.

These principles, which are the valuable result of observation, are almost entitled to the rank of laws of auscultation, the knowledge of which is eminently useful to diagnosis: accordingly, *sub-crepitating râle* perceived at the base of both lungs, indicates bronchitis: *sub-crepitating râle* at the summit of one or both lungs, indicates local tuberculous bronchitis, or tubercles in the state of softening.* Independently of this difference of seat, sub-crepitating râle, which is produced in the bronchiæ, or which is formed in the small pulmonary excavations, displays various shades of difference. The bubbles are denser, more viscid and superficial in proportion to their size, and there is then more reason to suppose the existence of small tuberculous caverns.

In *hemoptysis* sub-crepitating râle varies in its seat, extent, and characters, according to the seat, extent and nature of

*See Note 2 H.

the disease, which has given rise to the hemorrhage: if a simple exhalation from the mucous membrane of the bronchiæ have furnished the blood, and if the râle have been perceived on both sides, it is probable, that it has occurred in both lungs, and if it occupy one side, that it has taken place in one lung only. We should, however, keep in mind, that this seat of the sub-crepitating râle does not always determine the original seat of hemorrhage, on account of the more protracted continuance of the fluids at the base of the organ, and on account of the transmission of the blood to different portions of the air passages, when this fluid ascends from the lung to the mouth, to be discharged. If the râle were distinguished by large bubbles at a fixed point, where we recognise at the same time signs of pulmonary excavation, it would imply that the hemorrhage has taken place in a cavern.

In *congestion* and *apoplexy of the lung*, sub-crepitating rhonchus, which often takes the place of crepitating râle, possesses no particular character worth mentioning (Vide crepitating râle, p. 67.)

Conclusion: Semeiological value.—Of all the diseases, which we have passed in review, the most common are, beyond comparison, bronchitis and tubercles at the commencement of softening: the manifestation of sub-crepitating râle, should put us in mind especially of these two diseases; and the knowledge also of the favorite seat of this râle, should guide us in the diagnosis. If the bubbles, from being very numerous at the base, diminish in proportion as the ear approaches the summit of the chest, the existence of bronchitis is almost certain; if, on the contrary, from being absent, or not very numerous at the base of the thorax, they become more and more evident and abundant, in proportion as we carry the auscultation to the summit, we should establish the diagnosis of tubercles in the state of softening.

Cavernous Râle.

Synonyms.—*Gurgling* (*Gargouillement* of some authors.)

Characters.—The *cavernous* râle is characterised by the bubbles being less numerous, large and unequal, and mingled cavernous respiration; it is this mixture, which forms its peculiar characteristic, and which seems to distinguish it from the sub-crepitating râle with large bubbles, with which it is often confounded, or exchanged at intervals. It manifests itself either in inspiration or in expiration, and frequently during

both acts. Its intensity is greater or lesser according as the cavern contains more or less liquid. In certain cases the physician hears it at a distance, or the patient himself may even perceive it; when the excavation is superficial, the agitation of the liquid may be felt, by applying the finger to the intercostal space. It is permanent, or appears only at intervals; at one time it occurs during every exploration; at another, it disappears, especially, when the patient has expectorated much, and it is then supplanted by cavernous respiration. At another time again it ceases in an instant, when a local obstacle prevents the air from entering the cavity; but it is frequently reproduced by a very deep inspiration or a fit of coughing. It is generally circumscribed at the summit of one or both lungs, within a space corresponding to the extent of the pulmonary excavation.

In some cases we hear the moist râle, with smaller and more superficial bubbles, characterised by a clear tone, but without that admixture of cavernous respiration, which we have already had occasion to point out, when treating of sub-crepitating rhonchus; these kindred characters of its seat near the summit of the chest, and of the other concomitant phenomena, make this râle the interpreter of small tuberculous excavations; on account of the smaller diameter of its bubbles, and of the minuteness of the caverns, where it manifests itself, it has been designated by the term *cavernulous.*

Differential diagnosis.—It is impossible to confound cavernous râle with any other species of moist râle, when it is well characterised by the combination of large bubbles, and cavernous blowing. When cavernous respiration is not present, it differs little from sub-crepitating râle with large bubbles; but in that case the restriction of the bubbles to the summit of the chest, renders this species of râle of equal value to diagnosis.

Physical cause.—The cavernous râle developes itself in cavities hollowed out in the centre of the pulmonary parenchyma; it is requisite for its production, that these cavities contain both liquid and air at the same time, and that they communicate with the bronchiæ by one or several orifices. It is owing to the current of the inhaled column of air bursting the bubbles at the surface of the liquid and vibrating in the cavern.

When one or the other of these conditions is absent, the râle disappears, or it presents characters different from what we have assigned to it. Accordingly, if the excavation be

entirely filled with liquid, there is only heard a moist rhonchus, without admixture of cavernous blowing, if, on the other hand, the cavity happen to be empty, and contain nothing but air, cavernous respiration will alone prevail. The râle may also be annihilated when, in consequence of the cavity containing little liquid, the communication with the bronchiæ opens above the level of that liquid. Finally, it ceases completely if any local obstacle, such as an accumulation of mucous in the bronchial tubes, prevents the air from entering the cavern. In other respects the number of the bubbles, their variable volume, and their viscidity, are generally corelative with the density of the liquid, and the capacity of the excavation.

Pathological signification.—It is evident from the foregoing remarks, that cavernous râle announces the existence of a pulmonary, tuberculous, or gangrenous excavation, or of an excavation formed either by an abscess, or by the softening of an apoplectic deposit. Sometimes, again, it indicates a pouch-like bronchial dilatation, or in very rare cases, circumscribed pleuritic effusion, which communicates with the bronchiæ. The cavernulous râle denotes the presence of small superficial excavations.

Analytical diagnosis.—M. Chomel has pointed out in his clinical lectures, certain characters of cavernous râle, by means of which it may be easily distinguished, whether it be produced in pulmonary excavations or in circumscribed pleuritic effusion, communicating with the bronchiæ. The rhonchus proceeding from a *cavern*, is generally limited and stationary, at the superior region of the lung, and diminishes in intensity, in proportion as we remove from the central point, where it is formed. It is different with the râle peculiar to a *pleuritic effusion:* a deep gurgling is much more frequently produced at the base of the chest, near the pulmonary perforation, is propagated from below, in the direction of the bubbles, which traverse the liquid, and resounds *with the same intensity* over a variable surface.

The cavernous rhonchus possesses no special character, by means of which it might be possible to determine the *nature* of the pulmonary excavation, except in circumscribed pleuritic effusion with perforation of the lung; the differential diagnosis may then be derived from the consideration of the seat of the râle, from the more or less frequent occurrence of the diseases, which terminate in the formation of caverns, and

especially from the comparative study of the local and general symptoms, (viz. cavernous respiration.)

Conclusion.—Semeiological value. If the cavernous râle coincide with cavernous voice, and if it occupy the summit of the lung, it will be the almost certain sign of a tuberculous excavation.

APPENDIX.

THE SOUNDS OF CRACKLING, CRUMPLING, ETC.

In addition to the abormal sounds, already described, and which, being very distinct and easy to recognise, follow a natural classification, there are several others, which are heard more rarely, or only at intervals, possessing characters less developed, and differing too much, by their attributes from those we have investigated, to be easily arranged in any of the preceding divisions. We have therefore brought them together in this appendix.

At one time we hear the sound of *crackling* (*craquement*), at another, various *cries;* and, again, something analogous to to the *dull clapping sound of a valve;* occasionally various other sensations are indistinctly perceived, which it would be difficult to express in language. Those who make auscultation their habitual study, may every day have occasion to meet with one or other of these varieties of sound; M. Fournet has described one of them under the name of *pulmonary crumpling sound*, (*froissement pulmonaire*).

According to him, (*loco cit.* p. 172), that sound conveys to the ear the *sensation of the rubbing of a compressed tissue upon a hard substance.* "It may display different features and degrees: 1st, In its most intense degree it resembles the creaking sound of new leather, which differs from that of pericarditis in this respect only, that its tone is somewhat more acute; 2d, In a less marked degree, it constitutes a species of plaintive sound or groan of various intonations, corresponding to the state of oppression of the patient, as also to the force and rapidity of the respiration; 3d, Finally, in its third degree, which is the weakest and most frequently observed, it puts us in mind of the gentle, rapid, and dry sound, which is elicited by blowing upon very fine paper, such as the dry and transparent paper (vegetable paper) which artists employ to sketch a plan or a map."

Does this description refer to a particular phenomenon,

the characters of which are well developed and clearly determined? Can we consider a sound as single, which conveys such different sensations? Here, a *creaking sound of new leather*, there, *a plaintive cry* or *groan*, at another place, the *delicate rustling sound* (*frôlement*) of silk paper, For our part, we have never met with this friction sound bearing such distinct characters as M. Fournet speaks of, and M. Andral, in whose wards the former distinguished observer has made his researches, has confessed to us that he has no fixed opinion concerning this sound. The pathological signification of the sound of pulmonary crumpling, is equally obscure, although M. Fournet alleges, that he has heard it, especially in the first stage of tubercles, in the proportion of one to eight, as also in a case of encephaloid tumour, and in a very large non-tuberculous cavern at the summit of the left lung, (*loco cit.* p. 175.)

In a very small number of cases we have witnessed a species of *plaintive cry*, especially during inspiration, which was, however, always heard by mere chance. Might this cry not constitute one of the varieties of pulmonary friction sound indicated by M. Fournet? This phenomenon has presented itself to us only at the summit of the lungs, and simultaneously, with other evident signs of tuberculous excavations (cavernous râle and blowing, pectoriloquy.)—In other equally rare cases we have heard, during inspiration, a rapid sound, analogous to the soft *clapping noise of a valve*, which continued longer than the cry, and which we have also found to coincide with other signs of caverns at the summit of the lung.

The existence of pulmonary excavations, appears to be one of the principal anatomical conditions, with which the manifestation of these sounds is connected; but it requires, undoubtedly, some particular disposition, that escapes our notice, either in the mode of communication of the cavern with the bronchiæ, or in the thickness and flexibility of their walls. When the sound of the clapping of a valve is heard, we might say, that a moveable obstacle shuts up the orifice communicating with the cavity, and that this obstacle is briskly displaced at each inspiration. Might it not be a fragment of pulmonary tissue, almost entirely detached by softening of the tubercles, but still adhering to the walls of the excavation by a pedicle, which, placing itself before the aperture of the bronchiæ, is lifted up with noise by the rapid current of the column of inspired air? Whatever may be the merit of

this explanation, which we give with great diffidence, we consider the following conclusion justifiable, that *these valvular sounds*, or *plaintive cries*, *indicate the existence of tuberculous excavations*, without, however, imposing the necessity of inferring the absence of disease from the absence of these sounds.

There still exists another abnormal sound, heard more frequently, the characters of which are more developed, and the importance of which to diagnosis is much more considerable, viz: *pulmonary crackling*. This phenomonon, the existence of which was known, and its pathological value determined, long before M. Fournet gave a more complete description of it, deserves particular attention.

Pulmonary Crackling.

This sound consists, as its very name indicates, in a succession of small and generally not very numerous cracklings, which are only heard during inspiration, and so much the more distinctly, the longer its duration, and the greater its force. From being more frequently dry at the time of their appearance, they assume a moist character at a later period, (moist crackling). In general they are only heard at the summit of the chest, and when they are perceived lower, than the subspinous and sub-clavicular regions, we commonly recognise at these superior regions, the physical signs of a more advanced pulmonary alteration. They coincide almost always with the phenomena accompanying the first stage of phthisis.

Differential diagnosis.—The dry crackling* differs from the râles by the absence of bubbles; when it becomes moist, it is easily confounded with the sub-crepitating rhonchus. It is distinguished from abrupt pleuritic friction in this respect, that the fits of the latter occasion a duller and more prolonged sound; it differs also in its seat, and especially in its progress, as well as in its concomitant and consecutive phenomena.

Pathological signification.—Although the mechanism of the production of crackling is not yet explained, we know at least the pathological conditions, to which it is attached. It has only been met with at the commencement of pulmonary phthisis.†—In its moist state it indicates softening of tubercles.

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* See note 2. I.

† See note 2. K.

SECOND ARTICLE.

Auscultation of the Voice.

§ I. *Particular Regulations.*

Let us add a few particular regulations to the precepts we have just been discussing, which we consider useful for the auscultation of the voice. What we have mentioned in regard to the posture of the patient, is here likewise applicable. In general, the sitting posture is preferable, as the auscultation of the voice is chiefly performed at the posterior region. In order that the vocal phenomena be appreciable, it is necessary that the patient speak with a certain energy, and with uniform intensity of sound, when we explore the different points of the chest. It is a common practice to make him cough, or read aloud with an equal and well sustained voice, in order that the ear, which always judges by comparison, may more correctly appreciate the morbid modifications in tone and intensity.

It is not altogether a matter of indifference whether we use the ear or the stethoscope, for the ear is more convenient in bronchophony, which is a widely spread phenomenon, and in ægophony, which is generally discovered at the inferior angle of the scapula, where the cylinder would be of difficult and inconvenient application. We prefer, however, the stethoscope in pectoriloquy, because the phenomenon is limited, and because the articulated sounds are readily transmitted through the instrument. If we use the cylinder, Laennec recommends the application of the plug; but we do not consider this precaution necessary. The pressure of the head upon the instrument, or upon the chest, ought to be moderate and uniform, both on the right and left side; too great pressure renders the resonance less pure and distinct; whereas too slight pressure changes its nature, and imparts to it a bleating character.

§ II. *Physiological Phenomena.*

On examining the larynx of a person in the act of speaking, we perceive a pealing resonance which traverses the tube of the stethoscope, and strikes the ear forcibly: the same phenomenon takes place at the lateral portions of the neck, and in some individuals even in the vicinity of the neck. The resonance, which is very loud at the sub-sternal portions of the

trachea, diminishes in the large bronchiæ, and in the corresponding points of the thorax. In other regions, provided the thoracic organs are in a perfectly healthy condition, we hear only a confused buzzing.

This buzzing, which in general causes the thoracic walls to vibrate, varies in intensity and tone according to the conformation and dimensions of the pectoral cavity, according to the points, where the ear is applied, and chiefly, according to the force and tone of the voice. It is loud and ringing, if the latter be loud and sonorous; duller, if it be deep; less distinct, if it be more feeble; absent, if it be extinct. The authors, who have been mostly occupied with auscultation, do not appear to have pointed out emphatically enough, the very powerful influence of the tone of the voice upon the nature of its resonance in the thorax. It is this fact, which accounts for the differences generally attributed to age: we explain them by its ringing sound in a well conditioned adult, its bleating tone in the broken tremulous voice of the old, its feebleness in women, whose larynx is much less developed, and in individuals possessing a loud and shrill voice. The vibrations are then often scarcely sensible in the interior of the chest, and communicate no trembling to the hand, when applied to the thorax. The voice of infants is generally very loud; and the vocal resonance is in them reduced to almost nothing, notwithstanding the thinness of the thoracic walls. Laennec has said, that it is very strong at the points of the chest, which correspond to the large bronchiæ; M. Fournet has copied him, by saying that the resonance was in all cases more ringing, than in the adult; an attentive observation, instituted at the Hospital for diseases of children, has induced us to adopt the very opposite opinion.

The conformation of the pectoral cavity, and the diversities of the regions in which we pursue our examination, likewise modify, as we have already noticed, the vocal resonance: it is more intense in proportion to the dimensions of the chest, and the thinness of its walls, and more feeble when the opposite conditions are more distinctly marked. The nearer to the large bronchial tubes the examination is made, the more conspicuous is the sound, and the further from the root of the lung, the more it diminishes: it is pretty loud at the superior portion, between the shoulder blade and the vertebral column, and decreases as we approach the base of the thorax. It is, besides, of equal intensity at the corresponding points of the two sides of the chest, with the exception of the summit of

the right side, towards the spine of the scapula, where it is somewhat better marked, on account of the more considerable volume of the principal bronchiæ. This difference in caliber has more influence upon the resonance of the voice, than upon that of the respiratory murmur. It ought, however, to be taken into account, when we would trace more minutely the pathological phenomena.

It follows, from what we have remarked, on the numerous variations of vocal resonance, that the natural intensity of the resonance of the voice cannot be absolutely defined. If we examine above the inferior angle of the scapula, and if the voice of the individual be feeble, his chest contracted, and the walls, at the same time compact, the resonance will be hardly perceptible, whereas, if we listen close to the spine of the scapula, when the voice of the individual is sonorous in tone, and his chest broad and attenuated, the resonance will be very loud, and at the same time normal. Properly speaking, the voice presents no absolute, invariable, and normal type; the same degree of trembling, which is natural in one, may be relatively too feeble in another, and too loud in a third; a *relative* type may, however, be derived from the resonance perceived in an individual who, in a moderate degree, possesses power of voice and breadth of chest, with compactness of its walls. If, in that case, we apply one ear very closely, and stop the other, we hear, during the act of speaking, a confused buzzing in the chest, which prevents us *from distinguishing* the words. If these conditions just alluded to, be increased, the words are rendered very distinct, and hence arises a species of *natural pectoriloquy.*

The considerations, which we have just particularized show us still more the importance of the following principle, that we *should always examine comparatively on both sides*, in order to find the normal type of the voice in the healthy side of the patient. But as similar physical alterations might exist on both sides at once, we should take into account the tone and volume of the voice, as well as the place, at which we explore, to be able to appreciate the value of vocal resonance in a given case. The neglect of these precautions might lead us to mistake normal differences for pathological phenomena, and *vice versa.*

Theory of the resonance of the voice.—Vocal resonance, which is perceived in examining the thorax, is not like the vesicular murmur, formed in the lung itself; it is nothing else, than the reverberation of the sounds produced at the superi-

or portion of the trachea, and the vibrations follow the bronchial ramifications till they reach the ear. It is, in fact, a phenomenon of transmission, as is proved by the diminution of the intensity of the sound, in proportion as we remove from the seat of its production.

§ III. *Pathological Phenomena.*

The natural reverberation of the voice represents the healthy condition of the respiratory organs; if these material conditions be altered, on the one hand, by modifications in the density of the pulmonary tissue, or in the form and caliber of the bronchiæ; and, on the other hand by the formation of cavities hollowed out in the parenchyma, the resonance of the voice undergoes various changes in intensity, tone, and character. Accordingly, when the tissue is condensed, the resonance is *increased*. If it be consistent to such a degree that the cells are obliterated, and the bronchiæ supported by indurated parenchyma, form tubes with solid walls, the voice is reinforced, and seems to reverberate in sonorous tubes (*tubular voice or bronchophony*); if the lung, instead of being composed of dense and resisting tissue, looses in volume, and is compressed by pleuritic effusion, the voice assumes a tremulous character, which renders it analagous to the voice of a goat, (*bleating voice or ægophony*); if the parenchyma have become the seat of caverns communicating with the bronchiæ, or if those tubes assume a pouch-like shape, and form species of cavities, the voice appears to re-echo in a hollow space, and we might sometimes say that the sounds come directly from the chest, as if the cavern were speaking (*cavernous voice, or pectoriloquy*); finally, if the lung contain a large excavation, or rather if the cavity of the pleura communicate with the bronchiæ, through a pulmonary perforation, the voice assumes a very peculiar metallic tone, as when a person speaks into the mouth of a large jug; this is called amphoric voice. Let us examine these phenomena in succession.*

*See note 2 L.

III. TABLE OF THE PATHOLOGICAL PHENOMENA OF THE VOICE AND COUGH.

1st. Pathological phenomena of the voice.	*A.* Exaggerated resonance. *B.* Bronchial voice or bronchophony. *C.* Bleating voice or ægophony. *D.* Cavernous voice or pectoriloquy. *E.* Amphoric voice.
2d. Pathological phenomena of the cough.	*A.* Bronchial or tubular cough. *B.* Cavernous cough. *C.* Amphoric cough.
3d. Phenomena furnished by inspiration,—the voice, and cough.	Metallic tinkling.
Appendix (Hippocratic succussion.)	Sound of thoracic fluctuation.

A. *Exaggerated Resonance of the Voice.**

Synonym.—Weak bronchophony.

Characters.—The resonance of the voice is more or less marked, and may approach to real bronchophony. This gradation is sometimes employed to express the different stages of the increasing morbid lesion. Although generally confined to the summit or to the base, it may occupy a greater area, either on one side or on both. It is a permanent phenomenon, which recurs every time the patient speaks.

Differential diagnosis.—As we cannot absolutely determine, where the natural resonance of the voice terminates, and where the morbid resonance commences, because there exist such numerous varieties of it in the normal state, (vide p. 80), it is necessary, as we have already mentioned, to explore carefully both sides of the chest in points exactly corresponding, in order to find a type of comparison in the healthy side; and as it may happen, that both lungs are equally affected, we must consider carefully the different physical conditions of the pectorial cavity and the voice, before we form our opinion. Exaggerated resonance distinguishes itself from the other morbid modifications of vocal resonance, in this respect, that, like true bronchophony, it is rather an alteration in intensity, whereas ægophony and pectoriloquy are chiefly alterations in tone and character.

Physical cause.—(vide *Bronchial voice*, p. 86.)

Pathological signification.—Exaggerated resonance and bronchophony (p. 86) have the same pathological signification; they are connected with similar diseases, which are, however, in general less developed and less extensive in the former case than in the latter.

B. *Bronchial Voice or Bronchophony.*

Synonyms.—Tubular voice, buzzing voice.

Characters.—Bronchophony is a very loud resonance of the voice in the interior of the chest. It is nothing but a higher degree of simple resonance, and of variable intensity. It does not always preserve the same characters; at one time the vocal vibration is clear and free, this is *pure bronchophony;* at another it is slightly tremulous, and is termed *bleating bronchophony*. It may occupy all the points of the lung, but

*See Note 2 M.

more frequently the posterior portion than the anterior; if it occur anteriorly, it is commonly to be found under the clavicles. Its extent is variable. Sometimes the resonance is circumscribed by exact limits, and it ceases suddenly at a line, beyond which its intensity becomes normal; at other places it appears feeble, and vanishes imperceptibly. It is commonly permanent at the regions, where it is discovered. Most frequently, succeeding a simple augmentation of natural resonance, it increases progressively, and thus makes room for cavernous voice, or it gradually decreases in the course of several days. Bronchial voice coincides during the greater part of the time with bronchial respiration.

Differential diagnosis.— Bronchophony differs from exaggerated resonance of the voice only by its greater intensity; it is distinguished from *pectoriloquy*, by being widely spread, and by the absence of cavernous respiration and râle; and from *ægophony* by its loud resonance, its inferior acuteness of tone, its less bleating character, its more variable seat, which generally occupies the summit of the chest, and by being stationary at the place, where it is recognised.

Physical cause.—The physical conditions, which coincide most frequently with bronchophony, are, partly a larger diameter of the bronchiæ, where it originates, and partly a greater density of the surrounding pulmonary tissue. We can easily form an idea of the production of the phenomenon, if the vibrations of the voice, instead of resounding in tubes with soft and flexible walls, instead of decreasing in their progress to more and more minute bronchial ramifications, and, instead of lessening during their transmission through an elastic and spongy tissue, are produced in tubes with a larger diameter, or are concentrated in the bronchial branches in consequence of obliteration of the vesicles, if they be at the same time reinforced by a denser tissue, which transforms the bronchiæ into tubes with firm and elastic walls, and, finally, if they be better transmitted by indurated parenchyma. The more numerous these morbid conditions are, the more the material diseases will be developed, and the more marked the phenomenon; it attains its maximum intensity in those cases, where the diameter of the tubes, and the density of the surrounding tissue are increased at the same time, as in certain dilatations of the bronchiæ with induration of the pulmonary parenchyma; in these cases the resonance is sometimes so loud, that it causes a painful sensation to the ear.

Pathological signification.—Bronchial voice has the same

morbid signification with *bronchial respiration*, we refer, therefore, to the chapter where we have treated of this modification of the respiratory sound, (p. 44). Uniform dilatation of the bronchiæ with condensation of their walls, or increased density of the surrounding pulmonary parenchyma, induration of the lung, from cancer, melanosis, apoplexy, &c., and especially from *crude tubercles*, or from *inflammation of the parenchyma:* these are the lesions which are proclaimed by bronchophony. Bronchial voice is also perceived as an exception, in *pleurisy with effusion.*

Analytical diagnosis.—If bronchophony exist without considerable dulness of sound on percussion, if it continue for weeks, months, or years, without fever, and without seriously affecting the general health, it becomes the sign of dilatation of the bronchiæ. If it be accompanied with dulness, it announces *pulmonary induration;* if the phenomenon, whatever point of the lung it may occupy, be very limited, and not very intense, if it continue for a long time without any marked change, the induration is probably connected with some rare accidental productions, melanosis, cancer, &c. If it begin suddenly in an individual suffering from an affection of the heart, with expectoration of pure blood, extreme oppression, &c., it is a case of *pulmonary apoplexy.* If it be recognised under the clavicle, in a patient, who suffered from hemoptysis, habitual coughing, emaciation, &c., if it be progressive, commencing with a slight, simple resonance, and be insensibly transformed into a louder resonance, the induration depends on a considerable congeries of *crude tubercles.* If bronchophony have attained its maximum intensity, if it occupy the inferior and posterior aspect of the chest; if it coincide with tubular blowing, and be met with in the course of an acute affection, there exists *hepatisation* of the lung, and if it diminish in intensity at the same time, that the returning crepitating râle becomes audible, it marks the resolution of inflammation of the parenchyma.

Some authors consider the existence of bronchophony in *pleurisy* as very common, and explain it by the compression of the pulmonary parenchyma, and the smaller branches of the bronchiæ, whereby the vocal vibrations are concentrated in the large bronchiæ. For ourselves, however, we cannot admit that proposition without restrictions: we do not deny the existence of *bronchial resonance* in pleuritic effusion, but we hold, that it is distinguished by peculiar characters from true bronchophony, such, for instance, as is observed in pneu-

monia. Indeed, the anatomical conditions differ considerably in both these affections; in inflammation of the parenchyma the lung is dense, and generally increased in volume: the bronchiæ are surrounded and supported by solid tissue, which increases the sonorous vibrations, and favors their transmission; their caliber is not changed, and their distance from the thoracic walls is the same. In pleuritic effusion, on the other hand, the tissue is only compressed and not indurated, and has lost in volume; the bronchiæ are flattened, their cavities more or less obliterated, and their distance from the ear increased, when the congestion is considerable. These natural differences lead us to presume, that the vocal phenomena, in both these diseases, are dissimilar.

Experience likewise confirms this supposition, and observation proves that vocal resonancc in pleurisy differs from true bronchophony it its seat and characters. Accordingly, the resonance is more circumscribed, and generally limitted to the inter-scapular region, corresponding with the large bronchiæ, which offers more resistance to the compression, and it seems to be produced at a distance, if the ear be in the least degree removed from this region. Hence it follows, that if, in a case where we have by other signs recognised a pleuritic effusion, the bronchial voice be heard with the characters of loudness and proximity, at a point not corresponding with the bifurcation of the bronchiæ, we have reason to think that pulmonary induration exists at the same time, and if this phenomenon show itself in an acute affection, we should infer the presence of *pleuro-pneumonia;* if it be perceived in the course of chronic pleurisy we should suspect *tubercles.*

Bronchophony, therefore, does not properly belong to pleuritic effusion: this latter is more clearly characterised by another vocal resonance, more remarkable for its tone than for its loudness, viz: *Ægophony.*

Conclusion: Semeiological value.—On account of the rare occurrence of dilatation of the bronchiæ, bronchophony indicates almost always a pulmonary induration; but *pneumonia* and *tubercles* are incomparably the most common of all the alterations, where the density of the lung is increased. It is more developed in pneumonia than in tubercles, because the conditions of bronchial voice are better fulfilled in the former disease than in the latter: it exists, only as an exception, in *pleurisy*, and indicates often, that the pleuritic effusion is complicated with *pneumonic* or tuberculous induration.

C. *Bleating Voice or Ægophony.*

Synonyms.—Ægophonic voice, *polichinello voice; voice of old age.*

Characters.—Ægophony is a particular resonance of the voice, of an acute, tremulous, and abrupt tone, very analogous to the bleating of a goat. According to the place, where it is observed, either in the vicinity of the large bronchiæ, or towards the posterior and inferior regions, it presents varieties of character and intensity: we might say at one time, that the sounds traverse a metallic speaking trumpet, or a cleft reed; and at another time, the patient seems to stammer like the "famous puppet Polichinello, whom the jugglers cause to speak with a counter between the teeth;" hence the strange but appropriate term of Laennec, *Polichinello voice.*

Bleating accompanies the articulation of the words, or rather it follows them like an echo; it is sometimes perceived, independently of vocal resonance itself. True ægophony bears a marked character of distance; in general, it seems to be produced at a certain distance from the ear. It does not show itself indifferently at all points of the chest, nor over an indefinite area: it is rarely met with over the whole extent of one side, and at the anterior or lateral portion of the chest; but is most commonly heard at the inferior half of the subspinous fossa, and is occasionally confined to a very circumscribed space, which corresponds with the inferior angle of the scapula; when it occupies a more considerable surface, it is greatly developed at this latter point. It sometimes shifts, when the patient changes his posture, when he leans to the opposite side, or when he lies on his stomach. Its existence is recognised at the second or third examination; but it generally does not continue for a long time: from five to eight days intervene between its appearance and its departure. It coincides most frequently with feebleness, or absence of vesicular murmur at the inferior portion of the chest, and, in certain cases, with bronchial respiration and voice.

Differential diagnosis.—Pure ægophony cannot be confounded with true bronchophony; the latter, which is remarkable for the simple augmentation of the resonance, distinguishes itself, besides, by its habitual coincidence with bronchial respiration, all these being characters the opposite to those of ægophony, the bleating sound of which, is its distinctive characteristic; sometimes, however, the two phenomena are mingled and confounded with the each other. The

shifting of ægophonic resonance, when the patient changes his position, serves likewise to distinguish the bleating voice from the cavernous, which is stationary, and commonly circumscribed at the summit of the chest, and accompanied by cavernous respiration or râle.

Physical cause.—Laennec attributed the bleating tone to the vibrations of the voice, in the compressed bronchial branches; vibrations, which are transmitted to the ear, through a thin and tremulous stratum of liquid. In consequence of the compression of the lung arising from the presence of pleuritic effusion, the bronchial ramifications, destitute of cartilage, become flattened, and are converted in some measure into a multitude of reeds, which occasion a tremulous resonance of the voice. But this circumstance does not seem to be the only cause of bleating, because ægophony ceases in contraction of the chest, in consequence of absorption of the pleuritic effusion, and because the flattening of the bronchial tubes sometimes continues, as is found on inspection after death.

The interposition of a stratum of liquid, susceptible of vocal vibrations, is a condition which appears necessary for the production of the phenomenon. The quantity of effusion, and the compression of the lung must have a certain limit, in order that this sound becomes manifest.* Laennec assigned to ægophony, as its most common seat, a zone from one to three fingers in breadth, which runs along the ribs from the centre of the scapula to the nipple, where the stratum of liquid has the smallest depth. If the morbid secretion be too abundantly formed, "so that the air penetrates but little and with difficulty, into almost completely flattened and obliterated bronchiæ, the resonance of the voice can only take place in that case, when the lung, entirely compressed and flattened against the mediastinum, is opposite to no other point than to the vertebral column." Laennec, in order to assure himself, that the presence of the liquid influences the manifestation of the bleating sound, placed a bladder filled with water upon the inter-scapular region of a young man, in whom the vocal resonance was naturally very loud: the voice appeared to him more *acute* and *tremulous.*

Certain pathological facts tend to prove the reality of the double influence, which we have pointed out. Dance recognised ægophony in a patient laboring under considerable

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* See Note 2 N.

hydropericarditis. One of us has noticed at the Hospital of La Charité, the case of a girl of 17 years of age, affected with rachitis, and who presented the signs of pleuritic effusion, (distinct ægophony, absence of the respiratory murmur, complete dulness on percussion); she died; and he was astonished to find on inspection, the lung elevated by an enormous accumulation of liquid in the pericardium, which filled the whole left cavity of the thorax.

Pathological signification.—The indication of the physical conditions necessary to the production of the bleating voice, suffices to determine precisely its morbid signification: true ægophony indicates a *liquid effusion into the cavity of the pleura.*

It still remains that the we should determine the nature of the liquid contained in the serous membrane; now, as the effusion of blood or of pus is not very frequent, and as, besides, the too great density of these productions seems to be an obstacle to the formation of true ægophony, it follows that this peculiar resonance indicates most commonly an accumulation of serum, in the pleural cavity, with or without traces of inflammation, in other words, *pleurisy* or *hydrothorax.*

The absence of the phenomenon, however, is not sufficient to prove the non-existence of these diseases, since it is manifested only under certain conditions: it is wanting, as we have seen, when the effusion is very considerable, and when it has compressed the lung completely against the mediastinum, or when there exist previous adhesions, which prevent the liquid from accumulating beyond a certain extent, or also in pleurisy with simple formation of false membranes, and inconsiderable secretion of serum; the bleating voice is likewise absent, or scarcely discernible, when the effusion is entirely chronic, or when it is circumscribed and confined to a small space.

Admitting the existence of ægophony, we yet consider it valuable, only in certain conditions. Indeed, as the voice in some individuals, and above all, in old women, has naturally a tremulous tone, and as bronchophony itself, is sometimes of a bleating character, ægophony indicates *pleurisy* with certainty only, when it is well characterised, when it exists but on one side, and when it shifts with an alteration in the position of the patient. We observe, moreover, that this last condition soon disappears, in consequence of the effusion becoming circumscribed by pseudo-membranous adhesions, which prevent the displacement of the liquid, and consequently that of

bleating. When ægophony is a sign of a less abundant effusion, it manifests itself during the earlier days, becomes noisy only at the third or fourth day, and remains for some time stationary. It may indicate the alternate condition of increase or decrease of the liquid: if the level of the liquid be much elevated, it disappears, and if it sink again, it is found once more (*returning ægophony*), until at length it finally ceases.

In one case, we have recognised the bleating sound even above the nipple. Laennec has seldom observed it over the whole affected side, and has twice ascertained, by inspection after death, "that this depended on the circumstance that the lung adhering here and there to the costal pleura, by a few bands, could not be pressed towards the mediastinum, and was consequently surrounded in its whole extent by a thin stratum of serosity."

The existence of ægophony on both sides, coinciding with other signs of pleuritic effusion, (complete dulness on percussion, diminution or silence of the respiratory murmur), would indicate *double pleurisy* or *double hydrothorax*. Complete apyrexia, and above all, the concomitant signs of general dropsy, would place beyond all doubt the existence of this latter affection.

If the modification of the voice approach to bronchophony, if it be at the same time characterised by bleating, and by powerful vocal resonance, we should establish *pleuro-pneumonia*. This complication would become more evident, if these two phenomena were perceived at the same time, and independent of each other; but the existence of pleuro-pneumonia would become indubitable, even in the first case, if on exploring the patient lying on the stomach, we heard crepitating râle, or superficial bronchial respiration, where we had just recognised ægophony and silence of respiration.

Conclusion: Semeiological value.—The multiplicity of the conditions necessary for the production of the bleating voice, and its often incomplete manifestation, are the causes why this phenomenon can seldom be applied with *perfect confidence* in our diagnosis. When it is well characterised, it indicates a *pleuritic* and *generally serous effusion*. If it be perceived on one side only, accompanied with fever, it is a case of *pleurisy;* if on both sides, without fever, and with general dropsy, it is a case of *hydrothorax*. If it appear in the course of inflammation of the pulmonary parenchyma, and

if it be displaced when the position of the patient is altered, it indicates *pleuro-pneumonia.*

D. *Cavernous Voice or Pectoriloquy.*

Synonym.—Articulate voice.

Definition.—Pectoriloquy takes place according to Laennec, when the voice seems to issue directly from the chest, and to pass through the hollow of the stethoscope to the ear. But this phenomenon, which is produced in a pulmonary excavation, manifests a well developed character, only in certain circumstances: in order that it should be distinct, it requires that the cavern be superficial, of moderate capacity, tolerably smooth in its intérior, and not traversed by bands, entirely or nearly empty, with thin but solid walls, and adhering to the internal surface of the thorax. As these numerous conditions are rarely combined, Laennec was obliged to admit several species of pectoriloquy "a *perfect species,* characterised by the distinct transmission of the voice through the stethoscope, by the circumscribed nature of the phenomenon, and of those phenomena which the cough, the râle, and the respiration, present at the same time: an imperfect species, when one of these characters is wanting, and above all, when the voice is not distinctly transmitted: finally, an *equivocal* species, when the resonance is very feeble, and can only be distinguished from bronchophony, by the aid of signs derived from the situation, where it occurs, from general symptoms, and from the progress of the disease."

The necessity, which obliged Laennec to admit these multifarious distinctions, proves how little the word pectoriloquy is capable of giving us a thoroughly correct idea of the vocal phenomenon, furnished by pulmonary excavations; what proves still more the inadequacy of this denomination, is his having been obliged to associate in his definition, other concomitant signs of caverns, with the characters of the voice. If we examine, moreover, attentively the characters of vocal resonance in the physiological or morbid state, we perceive that in some individuals endowed with a powerful voice, and the walls of whose chest are not very thick, the words resound so loudly and so distinctly in the pectoral cavity, that they seem to be precisely formed at the point where the examination is made, and this constitutes true pectoriloquy. We observe, likewise, that in some species of pleurisy, auscultation reveals an analogous phenomenon, and the ear distin-

guishes the words distinctly, as if they issued from the chest itself.

The true pectoriloquy of Laennec, is, therefore, a sign but rarely appreciated in a disease of such common occurrence; the characters of this phenomenon are in the greater number of the caverns less developed; and it may even fail entirely in some of them. Pectoriloquy may, besides, manifest itself without the presence of excavations. And we believe that this term may be productive of error, that this mode of viewing the vocal modification restricts the application of this sign, and renders it less useful, and that we should rather substitute for it the term of *cavernous voice.* Indeed this expression would be more correct, because in individuals affected with tubercles, the voice seems evidently to resound in a pulmonary excavation, although it does not exhibit the conditions of Laennec's pectoriloquy; this term establishes a more exact and constant relation between the vocal modification and the material conditions which produce it; and the phenomenon thus considered, furnishes a sign of more frequent occurrence, and of surer practical utility.*

Characters.—If, on examining a patient in the act of speaking, the vocal vibrations appear to be concentrated in a hollow space, the walls of which reflect to the ear sounds more or less distinctly articulated, we would call it *cavernous voice.* Its various degrees of intensity and tone depend upon the power and tone of the voice, as also on the material condition of the cavern. At one time it is ringing: the sounds appear to issue directly from the chest, and pierce the ear: the auscultation on the larynx or on the lateral regions of the neck, conveys a perfect idea of this variety; at another it is scarely perceptible; in other circumstances, it exhibits, although it is very feeble, a particular character, for example, when the softening of pulmonary tubercles coincides with ulcerations of the larynx, the faint voice of the consumptive patient gives rise to a *subdued cavernous voice:* we might say that the patient speaks in a low tone into the tube of the stethoscope. Cavernous voice is most frequently heard at the summit of the lung, at the superior half of the chest, and is generally circumscribed. It is commonly permanent, and its intensity varies according as the cavern is full or empty. It coincides either with cavernous râle, or more particularly with cavernous respiration.

* See Note 2 O.

Differential diagnosis.—*Cavernous voice* conveys sometimes to the ear, a sensation somewhat analogous to that of *bronchophony;* but there exists a difference in the seat of the two phenomena, as well as in their extent, the former being more frequent at the summit of the chest, and the latter at the base and root of the lungs; the one is generally circumscribed, the other diffuse, and perceived over a more considerable surface. They differ, moreover, in their concomitant physical signs, for cavernous blowing and râle accompany pectoriloquy, whereas harsh or bronchial respiration coalesces with bronchophony.

Sometimes it is difficult to establish a distinction between the resonance of the voice in a cavern, and between bronchophony produced at the summit, in the dilated bronchiæ; indeed, on the one hand, the two vocal modifications become confounded, and occupy the same seat, on the other hand, we can no longer depend on the differences between the coinciding acoustic phenomena, since the respiration exhibits morbid characters, and since it may resemble a cavernous râle, though it be formed in the bronchial tubes, when a moist rhonchus has made its appearance. In these obscure cases we should assist our diagnosis by having recourse to the general symptoms, and to the progress of the disease.

Except in pulmonary caverns of a flattened form, and of pliant walls, when pectoriloquy occurs accompanied by a vocal and somewhat tremulous character; the difference between the *bleating* and cavernous voice is tolerably distinct (*vide ægophony*, p. 89,) so that we require no reasoning to compensate for the defects of the ear.

Physical cause.—The mechanism of the production of cavernous voice, is almost identical with that of bronchial voice: the superior strength of vocal resonance depends on the vibrations being increased in a space, the dimensions of which are more considerable than that of the pulmonary cells and small bronchiæ, in cavities, the solid walls of which vibrate and reflect the sound forcibly.* The undoubted presence of pectoriloquy when certain physical conditions are combined, and its inferior intensity when they are absent, demonstrates the accuracy of this explanation.

The conditions most favorable to the clear and distinct production of the phenomenon are, the mean capacity of the cavity, the density of its walls, its complete vacuity, its

*See Note 2 P.

free communication with one or several bronchial branches, its proximity to the surface of the lung, its intimate adherence to the thorax, which thus constitutes one of its walls. If, on the contrary, the excavation be very small, the resonance of the voice becomes hardly perceptible: if it be large, but encompassed by sinuous and soft walls, if the surrounding tissue be not condensed, if the cavern be central, or without communication with the bronchiæ if these bronchiæ be too numerous, and, finally, if they be obstructed by a discharge of blood, all these circumstances taken together will be as many causes of diminution, or even of obliteration of cavernous voice. Laennec has likewise remarked, "that pectoriloquy ceases almost always, 1st. When the excavation opens into the cavity of the pleura, and especially when the communicating aperture is large, and the passage short; 2d. When the matter contained in a cavern, forces its way through the thoracic walls, and infiltrates into the external cellular tissue.

Pathological signification.—We may here repeat what has been said in the chapter treating of cavernous respiration and râle, (p. 47 and 74). Cavernous voice indicates the presence of a pouch-like bronchial dilatation, or of a tuberculous, purulent, apoplectic, gangrenous, hydatid excavation, and cavernous voice, displays its peculiar ringing character chiefly in the tuberculous cavities peculiar to chronic consumption, and in those produced by pouch-like dilated bronchiæ, with coincidence of pulmonary induration.

Conclusion: Semeiological value.—We conclude, *from the rare occurrence* of pouch-like bronchial dilatations *and* of pulmary excavations, succeeding gangrene of the lung, abscess, apoplexy, &c., when contrasted with the frequent occurrence of caverns in phthisis, that nine times out of ten, cavernous voice indicates a tuberculous excavation: and almost nothing will be wanting to the certainty of this diagnosis, if there exist feeble cavernous voice.

E. *Amphoric Voice.**

Characters.—The best definition of amphoric voice, is that, which is derived from its very name; the comparison made by Laennec is most accurate: the resonance, of the voice of the patient is precisely similar to the metallic and cavernous buzzing produced by speaking into the mouth of a jug, which is three parts empty.

* See Note 2 Q.

Physical cause.—Amphoric voice depends on a modification of the vocal vibrations, where, instead of being propagated from the larynx to the last ramifications of the respiratory apparatus, with a gradual loss in intensity, they resound powerfully in a large cavity filled with air. In proportion to the size of the excavation, the quantity of air is more or less considerable, and the metallic resonance more or less distinctly developed. A certain quantity of liquid in the cavity does not form an obstacle to the production of the phenomenon; but it decreases in almost a direct ratio with the accumulation of that liquid. It is moreover requisite, in order that the amphoric tone may be developed, that this cavity communicates with the bronchiæ, (pneumo-thorax with pulmonary fistula).

Pathological signification.—It is absolutely identical with that of *amphoric respiration*, (vide p. 50).

THIRD ARTICLE.

Auscultation of the Cough.

The semeiological value of the cough is inferior to that of the voice, as that of the voice is inferior to that of respiration. We have indeed seen, that there exists not one single material disease of the pulmonary organs, however slightly developed, which does not manifest itself, in the vast majority of cases, by one, if not by several alterations of the *respiratory sound*, and some of those morbid phenomena have a very precise pathological signification; indeed, several of them, *e.g.* crepitating râle, amphoric respiration, tubular blowing, are the almost pathognomonic signs of certain diseases of the respiratory apparatus. Another advantage, which is very valuable for the sure construction of the diagnosis, is, that their examination, though prolonged, occasions, when conducted with proper precaution, no fatigue to the patient, who does not even require to engage his mind in the medical investigation.

The case is, however, quite different, as regards the stethoscopic signs furnished by the auscultation of the *voice;* they are less numerous, and possess far less precise characters, besides, the sounds frequently resemble one another to such a degree, that they become mutually confounded. Their utility for semeiology is, therefore, more restricted, and when this

manifestation is not very evident, they are often of less importance in themselves than in their combination with other phenomena: thus it happens that certain morbid modifications, which are almost valueless in themselves, receive importance only by their alliance with alterations of the respiratory sound, or of the sonority of the thorax. Suppose, for example, a slight resonance of the voice to be perceived at the summit of the chest, its pathological signification, which in itself would be very vague, will only receive a decided value, when it is associated with harshness of the respiration, or with dulness on percussion.

Besides, the production of the vocal phenomena is often impossible: an infant, incapable of reasoning, a patient in delirium, or in coma, or an individual, whose voice is enfeebled, could in no way assist the physician, who thus finds himself deprived of one of his resources; those patients, even, who are able to further his researches, get soon tired of speaking, and the examination could not be prolonged beyond a very short period. *Autophony* compensates but incompletely for these defects accompanying the auscultation of the voice.

It is even worse with auscultation of the *cough;* the signs, which it furnishes are not more easily obtained, and if they be sometimes perceived pretty rapidly, the number of the pathological modifications is too restricted, and their characters are, with some exceptions, too little defined to satisfy the diagnosis, unless we are previously enlightened by the investigation of the phenomena of respiration, and of the voice.

The cough serves most frequently only as a means of controlling or confirming our first judgment. We shall not enlarge on this application of stethoscopy, which is rendered almost superfluous, because the knowledge of the alterations of the respiratory sounds, and of the voice, strengthened by the results of percussion, has been found sufficient to establish a certain diagnosis.

The cough adds, therefore, to semeiology very few positive signs of its own, it is rather a means of provoking the manifestation of abnormal sounds, the physical conditions of which are already in existence. The very circumstance that it is accompanied by more rapid expiration, and followed by more energetic inspiration, is a reason why it unfolds or exaggerates certain phenomena, which otherwise would not have been produced, or would have been left indistinct. Accordingly, in order to satisfy ourselves, that the respiration is natural, we have said, that it is a rule to desire those individ-

uals, who are unable to breathe freely, to cough forcibly: the long inspiration, which necessarily precedes the cough, will afford the means of deciding, whether the feebleness, or absence of the vesicular murmur, be real or only apparent; this precept is still more applicable to children, who are incapable of controlling the respiratory movements.

The same remark extends to moist râles: as they are caused by the air traversing the liquids contained in the air passages, they are much more surely produced, and become much more perceptible, the more the course of the elastic fluid is accelerated: crepitating râle, which is hardly manifested in the ordinary movements of distention of the chest, shows itself in the deep inspirations of the cough; hence it is important to engage the patient to cough at the commencement, or at the termination of pneumonia, and in the case of partial sanguineous or serous engorgements of the lung, in order that the air may penetrate the greatest possible number of the cells, and reveal to the ear phenomena, which, without this excess of respiration, would have remained dormant, or too feeble to be perceived. Occasionally a momentary obstacle prevents this manifestation, by changing the material conditions of the parts; this might be, for example, an accumulation of mucus obstructing the orifice communicating between a bronchia and cavern: so that when the cough, by expelling these productions of bronchial secretion, has reestablished the communication, the cavernous respiration or râle, will once more make its appearance, along with the primitive conditions of its production.

In some circumstances we may know, through the medium of the cough, whether a phenomenon be permanent or transient, by ascertaining, whether it continue or cease after this act, and after the subsequent expectoration. Accordingly, the respiratory sound, which appears feeble in one point, owing to the momentary obstacle, which the sputa, arrested in the bronchiæ, opposes to the current of air, will reappear in its natural character, after the expulsion of the mucus, and on the other hand, when the feebleness of the respiration lasts, after the fit of coughing is over, it indicates a permanent disease, for example, tubercles. In the same way sonorous or sub-crepitating râle, allied to the accidental presence of mucus in the air passages, will disappear after the evacuation of the bronchial secretion, whereas the permanence of the abnormal sounds should be associated with more stationary, and consequently more serious alterations.

The cough serves for the differential diagnosis of several analogous phenomena, and for the determination of their precise seat. We have observed, that pleuritic friction offers, in one of its forms, a very great resemblance to dry sub-crepitating râle, that it is often difficult to distinguish the true cause of two sensations so strongly analogous. Desire the patient to cough, and if you observe, that the abnormal sound persists without any modification, it is a case of *friction sound* occurring in the pleura, external to the air passages; if, on the contrary, the râle cease after expectoration, or be considerably modified by the shocks imparted to the air, it is then formed in the bronchial tubes.

It is evident, from what precedes, that the cough is sometimes a profitable means of abridging the stethoscopic investigation; accordingly, the diagnosis may, in some cases, be accomplished with extreme alacrity, for example, in patients too feeble to endure a long investigation, or in children, too impatient to submit to a tedious examination. However limited our experience may be, a single fit of coughing suffices in general to make us perceive all the signs, which it is capable of furnishing, whereas it requires several inspirations to obtain the same result.

After these preliminary considerations, we have but little to add, in explanation of the method of proceeding as regards the investigation of acoustic facts, revealed by the auscultation of the cough. The greater part of the rules, which refer to the auscultation of the voice are here again applicable. We need only farther remark, that there are some individuals, who do not know how to cough or how to breathe freely; they cough as it were *from the extremity of the lips;* and it is necessary to ask them to utter a deep sigh, so as to cough *from the bottom of the chest*, whereby a strong shock is imparted to the whole column of air.

The *physiological phenomena* are observed as follows: the ear applied to the chest perceives at the moment of coughing, a dull and confused sound, accompanied by a shock, which shakes the pectoral cavity. This phenomenon of mixed impulse and sound, more easily discerned by the senses than described, is so much the more perceptible, the nearer it is to ear, or the more voluminous the bronchial tubes, in which it occurs, and the more forcibly the patient coughs; but it is less remarkable under the opposite conditions. The cough, which is heard over the larynx and the trachea, and in persons with a narrow chest, at the root of the bronchiæ, con-

veys, moreover, the sensation of hollowness, or of the air traversing a tube.

Pathological Phenomena.

In the pathological condition the cough presents sometimes special characters; the principal sensations which it conveys to the auscultator have received the epithets of *tubular*, or *bronchial*, *cavernous*, and *amphoric*.

A. *Tubular or Bronchial Cough.*

When the respiration and the voice are *tubular*, the cough is likewise so, and always in direct proportion; the shock which it communicates to the walls of the thorax is very energetic, and the ear perceives the sensation, which a column of air would cause, by traversing with great noise, force and rapidity, tubes with solid and as it were metallic walls.

It is generally more perceptible towards the root of the lung, "and sometimes more evident at the points, where the larger bronchial branches have scarcely the size of a small goose quill, than it is in the trachea, in the natural state."

It is manifested under the same conditions with bronchial respiration; in other words, its pathological signification is the same. It is sometimes recognised in *moderate dilatation of the bronchiæ*, especially with increase in density of the surrounding parenchyma; it occurs much more frequently in *induration of the pulmonary tissue*, caused by the accumulation of crude tubercles, and principally by the *hepatisation* of pneumonia. It is also met with in *pleuritic effusion*, but it has in that case particular characters; we might say, that the air traverses the flattened tubes with noise, and the phenomenon is besides, limited to the root of the lung, in the neighborhood of the large bronchiæ, and seems to originate at a distance from the ear when applied to the base of the thorax, whereas, in hepatisation, it may exist at variable points, and be heard so far as the inferior portion of the chest, presenting at the same time a distinct character of proximity.

B. *Cavernous Cough.*

Cavernous cough consists in a resonance, which is louder, and especially more *hollow*, than that of the normal cough. It is met with in all cases, where cavernous respiration ex-

ists, and sometimes even in the absence of the latter. It is accompanied by a considerable impulse upon the ear; the sensation of jerking, which it occasionally conveys, and of a shock, remarkable for its limited extent, is peculiarly characteristic.

Cavernous cough requires for its production the same conditions with cavernous respiration, and consequently the same pathological signification. *It is one of the most certain signs of pulmonary caverns;* and the nature of these excavations is determined by the considerations, which we have already explained. (vide p. 49.)

When pulmonary caverns contain a certain quantity of purulent matter, the column of air violently agitated by the cough, imparts to the liquid a brisk and powerful shock, and a mixed phenomenon becomes discernible, which has received the name of *cavernous cough and râle.* This phenomenon is the more remarkable when the excavation is more superficial; it is rendered more evident, when a moist râle accompanies cavernous respiration, and is produced even in cases, where the rhonchus becomes scarcely manifest during the ordinary inspirations. It is also one of the surest signs of the existence of a *cavern containing liquid.*

C. *Amphoric Cough.*

Amphoric cough is characterised by a greatly developed metallic resonance, which is to the normal cough, what amphoric respiration is to vesicular respiration; we may imitate it by coughing into the mouth of an empty jug. It is always recognised during the presence of amphoric respiration and voice, and frequently even in the absence of these phenomena.

The analogy of the characters of amphoric cough to those of amphoric respiration, should lead us to presume, that it is allied to the same physical conditions, viz: to the existence of a very large cavity communicating with the bronchiæ; with this exception, that the air, instead of penetrating more or less slowly into this vast excavation, is there briskly and impetuously compressed. This brisk penetration of the column of air gives sometimes rise to the production of a species of *argentine tremors*, or of *metallic clapping*, which is a sure sign that the cavity contains liquid. We may, moreover, judge from the circumstances mentioned under the head of ampho-

ric respiration, whether it be a case of a *large tuberculous cavern*, or of *pneumo-thorax with bronchial fistula.*

Metallic Tinkling.

After the description of the different pathological phenomena, furnished successively by the auscultation of respiration, the voice, or the cough, we have now to speak of an abnormal sound accompanying each of these three acts, which is called metallic tinkling.

Characters.—Laennec has designated by this name "a singular phenomenon, which consists in a sound perfectly analagous to that emitted from a cup of metal, glass, or porcelain, when struck gently with a pin, or when a grain of sand is dropt into it." It may be heard when the patient breathes, speaks, or coughs, and coincides commonly with inspiration, rarely with expiration alone, and sometimes with them both; it is also manifested, as an exception, when the patient rises from the dorsal decubitus into the sitting posture.

It is not perceived with the same frequency and distinctness under the following different conditions: during respiration it is habitually less distinct, and occurs only at intervals during powerful inspirations. It is more constantly, and much more evidently produced by the voice and cough; this latter is sometimes alone capable of disclosing it; nevertheless, it is commonly perceived during the act of speaking, and we must then take care that the patient articulates each syllable strongly and clearly, leaving an interval between each; we obtain this result by directing him to count slowly, but with a loud and abrupt voice; at the end of each syllable we hear an argentine metallic sound, perfectly analagous to that produced by a lead drop falling into a copper basin. This constitutes the loudest degree of tinkling.

Instead of a resonance thus characterised, we perceive sometimes an argentine sound analagous to the vibration of a metallic cord when touched by the finger. Moreover, at one time the phenomenon is distinct, and remarkable for its metallic resonance, whilst at another these characters are less developed; at one place it seems to be produced close to the ear of the observer, at another it appears more distant. Its habitual seat is the mean lateral, or posterior portion of the thorax, whence the sound is propagated over a large surface, or it is observed at the summit of the chest, and in that case it is almost always limited. In other cases the situation may

vary in the course of several days, and, for example, the tinkling show itself at first at the upper part of the inferior angle of the scapula, and afterwards on a level more contiguous to the arm pit, (*Louis*, *Recherches sur la Phthisie*, 38 obs).

Metallic tinkling is sometimes permanent, and appears, whenever the patient speaks or coughs; sometimes it is transient, and only produced accidentally by strong paroxysms of coughing. Occasionally also, after having continued for some time, it ceases and reappears, and continues to do so, alternately for several times. It often commences with amphoric buzzing and with argentine tremors, being after the expiration of some days transformed into regular tinkling. Sometimes it coincides with cavernous respiration and râle, and with the sound of a *cracked pot;* more frequently it is accompanied by tympanitic sonority of the thorax, and coexists or alternates with amphoric respiration.

Differential diagnosis.—This tinkling is so characteristic, that it is impossible to confound it with any other phenomenon; once heard it cannot be mistaken, and the moment it strikes the ear, we cannot but divine its presence. In some cases, on examining the precordial region, we occasionally hear a species of metallic tinkling, which originates in the stomach, when distended by gas and liquid; this sound, which is altogether accidental and transient, differs too much from metallic tinkling, which is permanently and regularly connected with the movements of respiration, to lead us into error. A species of tone of the sounds of the heart, has likewise improperly received the name of *metallic tinkling*. We shall see (*Auscult. of the heart*), that the resemblance is merely in the name, and that they differ completely in the character of the sensation. There is, however, nothing easier in analysing these two stethoscopic phenomena, than to assure one's self, that the one coincides with the impulse of the heart, and the other with expansion of the lungs.

Physical cause.—The conditions necessary for the production of metallic tinkling are, 1st. The existence of a large cavity containing liquid and gas; 2d. A movement imparted to the fluids, enclosed in that cavity, by any cause whatever, and the particular sonorous vibrations, which take place in consequence. If, for example, in a case of pneumo-hydrothorax, with a fistulous communication between the pleura and bronchiæ, or in a case of a large cavern containing air and purulent matter, we direct our patient to breathe strongly, or what answers better, to speak or cough; if, in a case of pneu-

mo-hydrothorax without perforation, we desire the patient to raise himself rapidly in bed, the conditions first mentioned are fulfilled.

What is the mechanism of the production of this sound?

We cannot undertake this investigation with too much caution: it is quite evident, that we should look for the causes of the manifestation of the phenomenon, only under the physical conditions previously alluded to: viz: the air, the liquid, and the walls of the cavity which contain them: but it is difficult to determine with precision, how far each contributes to the formation of the sound. According to Laennec, the tinkling depends on the resonance of the air agitated by the respiration, the cough, or voice at the surface of the liquid: but this explanation, which is somewhat vague, appears to us incomplete, because it omits one circumstance which is generally connected with the production of the phenomenon. Indeed, if we try to reproduce the sound under the previous conditions only, for example, if we blow, speak, or cough into the mouth of a jug three parts empty, the resonance of the agited air produces, as we have already said, artificial amphoric blowing, voice and cough, but nothing analagous to regular tinkling.

The hypothesis of M. Raciborski is by no means applicable to all cases: it attributes metallic tinkling, "to the clapping sound which arises from the collision of the molecules of the liquid, contained in a vase with sonorous walls, the greater part of which is filled with air," after it becomes agitated by the concussions owing to the cough, or the voice, &c. If the argentine tremors in that species of tinkling designated by the name of clapping, become intelligible by the effects of their concussions, the latter afford in their turn, no explanation of the manner in which the singular sound is formed, and which is so perfectly analagous to that metallic sound produced by the fall of a lead drop into a copper basin.

Dance, who was the first to question the opinion of Laennec, expressed himself thus: "the mechanism of metallic tinkling seems to be the following: a certain quantity of air insinuates itself during the act of speaking, coughing, or breathing through the pleura bronchial fistula, and bubbles up to the surface of the liquid contained in the cavity of the pleura, forming more or less voluminous bubbles, which bursting at the surface of the liquid, shake the elastic fluid contained in the cavity of the pleura, and impart to it the character of resonance belonging to metallic tinkling. From the bodies of

individuals, who died of an affection capable of giving rise to metallic tinkling, we have several times elicited the sound, by injecting air through the trachea, when, on opening the chest, we saw large bubbles of air burst at the surface of the liquid."

The theory of M. Beau is the development of that of Dance: "the tinkling to which he proposes to give the epithet of the bubbling sound, (*bullaire*) is produced according to this ingenious observer, by the *rupture of a bubble of air in the midst of a thoracic, pleuritic, or cavernous effusion*, the walls of which are endowed with metallic sonority. The formation of this bubble always supposes the presence of a certain quantity of liquid, which it has to traverse before it arrives at the gaseous effusion, and a fistula, opening into the liquid, by which the air is introduced, and thus by its momentary submersion assumes the form of a bubble. In the great majority of cases, the bubble is owing to the entrance of the air into a bronchial fistula, which terminates below the level of the effused liquid. Sometimes the fistula does not open into the liquid, but its outlet is in a collection of puriform matter, which separates it from the gaseous effusion, so that the air which traverses the fistula raises up, in passing, under the form of a bubble, the collected matter, and that the rupture of the bubble takes place on the surface of the effused liquid, producing constantly the same metallic sound. Finally, we may also admit, that these tinkling bubbles can be produced by the exhalation of gas, at the surface of an effused liquid without bronchial communication, and that sometimes even they may result from the introduction of air into the cavity of the pleura, owing to a communication with the stomach or intestines. Of these different sources of bubbles, bronchial fistula opening into the effused liquid, gives undoubtedly the most positive results, and is most frequently observed."

According to this hypothesis, a single sound of tinkling is tolerably well accounted for, by the rupture of a single bubble of air on the surface of the liquid, and argentine tremors, by the successive and rapid rupture of several bubbles; but if we adopt it without restriction, how shall we explain the production of the phenomenon in those rare cases, when according to Laennec (T. II. p. 584, *ed. Andral*,) the pulmonary fistula is situated above the level of the liquid? M. Beau supposes that the bubbles are then formed, by the passage of air through the puriform matter of an abscess contiguous to the fistula. Of whatever value this explanation may

be, we still require to find another for accidental tinkling, which manifests itself the moment the patient assumes the sitting posture.

Laennec attributed the metallic sound, which is sometimes heard in this change of position, to the collision of a drop of liquid with the surface of the effusion, when in the act of sitting up, a drop adhering to the thoracic walls, falls from the top to the bottom of the pleural cavity. This mechanism it is easy to conceive: the false membranes, which line the superior portion of the pleura, may in the dorsal decubitus of the patient, be immersed in the accumulated serum, and retain some drops, which fall back upon the mass of the liquid, when he is about to sit up. But it is evident, that, if such be really the cause of metallic tinkling, in this particular case, we cannot establish it as a principle for a general explanation, for the phenomenon is produced nearly as often as the patient speaks or coughs, and we are not inclined to admit, as M. Raciborski fancies, that the impulse imparted by these acts to the liquid of the cavity is always strong enough to isolate from the mass several drops, which, falling back on the surface, occasion a sound of metallic clapping.

Are we to prefer any one of these theories to the exclusion of the others? We leave the facts to speak for themselves. It follows from several experiments of Laennec, that tinkling is not always characterised by bubbling, he says, (*loco cit.* T. I. p. **141**,) that he heard metallic tinkling in the cavity of the pleura, after the operation of empyema; "when the fluid was directed gently and by jets into the chest, without touching its walls, the naked ear perceived the sound produced by the injected liquid falling down in drops upon that already in the cavity, and this fall gave a very distinct indication of metallic tinkling: moreover, the air entering at each inspiration into the cavity of the pleura, and reissuing from it during expiration, produced a very distinct sound of amphoric buzzing."

M. Fournet has likewise made experiments on a patient, who had undergone the operation of empyema. A female catheter being introduced into the wound, and plunged into the mass of the liquid, injections were thrown by means of a syringe charged with air and water. "As long as the column of liquid entered into the cavity of the pleura, we heard nothing but a species of bubbling, but the moment successive and detached bubbles of air escaped from the syringe, and traversing the stratum of fluid, burst on its surface, an isolated sharp metallic sound became distinctly audible, which was repeated

at the rupture of every new bubble, and became at length quite analagous to the isolated sound of metallic tinkling, heard in the same individual on the same side of the chest, when he was allowed to breathe freely. Amphoric respiration is very well imitated by injecting the column of air directly into that portion of the pleural cavity, which is unoccupied by the liquid."

Analogous experiments have been made by the American physician, Dr. Bigelow (*Archives*, January 1840, p. 116,) on the body of a patient who died from pneumo-hydrothorax, and these experiments gave an entirely similar result. Dr. Bigelow repeated them in the following manner: "A bladder and a stomach containing several ounces of water, were completely distended by inflation. When the tube, through which the air was injected, was plunged into the liquid, the process of inflation being continued, the bubbles that formed, gave rise, by their bursting, to metallic tinkling. The sound became more and more metallic in proportion as the injected air increased the tension of the pouch. The succussion of the bladder produced the same sound. When the aperture of the tube was placed above the level of the trachea; and even when the bladder was empty, the inflation caused a strong amphoric buzzing, and if the saliva, or a small quantity of another liquid filled a portion of the tube, a feeble or sub-metallic tinkling was discernible."

In regard to tinkling, we have found, neither in the particular facts published by authors, nor in our own observations, sufficient reason to adopt one theory to the exclusion of the others: again, in reliance on the preceding experiments, we admit that the cause is manifold; that the tinkling depends most frequently on the rupture of a bubble of gas on the surface of the liquid, and that it results occasionally from the collision of liquid molecules on the surface of the effusion, and we shall confine ourselves to the eclectic method, until a more rigorous and complete observation has given us more satisfactory notions regarding the mechanism of the phenomenon.

However this may be, the intensity of metallic tinkling depends on the condition of the media, where it manifests itself: it becomes the more conspicuous the more considerable the capacity of the excavation, and the more equal the quantity of liquid and gas contained in the chest. If we perceive the tinkling above, whilst the patient breathes or speaks we may conclude, that the pulmonary fistula is situated below

the level of the liquid; if the amphoric respiration be heard without tinkling, the fistulous orifice is placed below, or somewhat apart from this level; it is close to it, when we hear argentine tremors; finally, when amphoric respiration and metallic tinkling appear together, we may presume, that the perforation is double or manifold, and that one of the fistulæ is placed below the surface of the liquid, and the other above.

Pathological signification.—Metallic tinkling may be heard, 1st. In pneumo-hydrothorax whether simple or complicated with fistulous communication between the pleura and bronchiæ; 2d. In a large excavation, hollowed out in the centre of the pulmonary parenchyma.

Analytical diagnosis.—1st. When pneumo-hydrothorax exists without *pulmonary perforation*, the metallic tinkling is heard, as an exception, only when the patient changes his position, (vide p. 108). We remark, however, that this accumulation of gas, exhaled from the surface of the pleura, or developed in its cavity, in consequence of the decomposition of sero-purulent matter, or of pus from an effusion, is a fact of rare occurrence. An attentive perusal of the observations reported by authors, as examples of simple pneumo-thorax (Laennec T. ii. Obs. 38 and 41), will convince us that, in several cases, a pulmonary perforation had caused the penetration of air into the cavity of the pleura, and that the ulcerated lung becoming afterwards cicatrized, occasioned the belief in the existence of pneumo-thorax. We have seen several cases, where this error might have been easily committed: the stethoscope had only revealed signs of a gaseous effusion without perforation; but, the false membranes found on inspection, the crude or softened tubercles met with at the surface of the lung, and the adhesion of the parenchyma to the thorax in that point, proved the more than probable existence of an old fistula.

Our opinion is confirmed by the fact, unfortunately rare, of the cure of pneumo-hydrothorax with pulmonary perforation; in these cases, the obliteration of the communicating aperture transforms the disease into simple hydro-pneumothorax; at the same time, amphoric respiration and tinkling disappear. and the presence of gas is only revealed by the greater sonority of the thorax, which diminishes in proportion as the elastic fluid becomes reabsorbed.

Moreover, metallic tinkling, in pneumo-hydrothorax, without perforation, is of less frequent occurrence than the tinkling of pneumo-hydrothorax with fistula, which is most

frequently elicited at every inspiration, at every fit of coughing, and at every word the patient utters, instead of being heard only once, and, as it were, by accident. It is accompanied neither by amphoric voice nor amphoric cough, which phenomena are generally inseparable from the tinkling disclosing the existence of a *liquid and gaseous effusion into the cavity of the pleura, with perforation of the pulmonary parenchyma.*

Metallic tinkling is heard shortly after the occurrence of an acute pain in the side during the progress of phthisis, more or less advanced, of pneumonia, or gangrene of the lung, or of a pleuritic effusion; if it coincide with extreme dyspnœa, with tympanitic sonority, and vaulted form of one side of the thorax, and if all these phenomena be manifested with remarkable rapidity, we ought to conclude that a spontaneous perforation of the lung has taken place, and, as its immediate consequence, the production of *pneumo-hydrothorax.* But, as we may easily prognosticate it, from what we have already observed, the absence of the phenomenon is no proof that this triple lesion does not exist: it may fail, if the pleura contain but very little liquid, or if the bronchial fistula open above the level of effusion, but the disease will discover itself by amphoric respiration. It is likewise wanting, when the fistula is blocked up, or if it open into a very small pulmonary cavern, which does not communicate with the bronchiæ, (*Louis, Recherches sur la Phthisie, Obs.* 39 and 42), provided it is not produced in an altered position of the patient, according to the mechanism indicated by Laennec.

2d. *A very large pulmonary excavation, containing a pretty considerable proportion of air and liquid*, would present the conditions requisite for the production of metallic tinkling, but the caverns, arising from gangrene, or from purulent softening of the lung, are seldom sufficiently large to give rise to the phenomenon; the above mentioned conditions occur more usually in pulmonary phthisis, where a great number of softened tubercles may produce large excavations. Now, the phenomenon in question will here exhibit some differences capable of deciding, whether our diagnosis refers to caverns, or to liquid and gaseous effusions into the cavity of the pleura.

In pulmonary excavations, metallic tinkling is never so constant nor so intense as that characterising pneumo-hydrothorax with perforation; it shows itself only at intervals, during severe fits of coughing, and is most frequently perceptible at the superior portion of the chest, and in a limited point,

whereas that of pneumo-hydrothorax resounds over a larger surface, and chiefly at the centre or inferior region. The other signs furnished by the stethoscope will remove any remaining doubt. Indeed, in a cavern, large bubbles of râle are simultaneously produced, or alternate with metallic tinkling, which does not occur in a liquid and gaseous effusion with fistula. In some rare cases, these two species of lesion may exist at the same time, and this combination is recognised by the concurrence of the signs formerly alluded to (p. 52), to which metallic tinkling is then superadded.

Conclusion: Semeiological value.—On account of the *rare occurrence* of caverns, even those of a tuberculous nature, which, by their volume and disposition, are susceptible of occasioning a *manifest* and *constant* metallic tinkling; on account of the still *greater rarity* of hydro-pneumothorax without pulmonary perforation, the semeiological value of well characterised metallic tinkling is *very considerable:* it is almost always the *pathognomonic sign* of a triple lesion, viz: of pneumothorax, liquid effusion, and fistulous communication of the pleura with the bronchiæ.

Sound of Thoracic Fluctuation.

We now proceed to the description of a phenomenon, which bears great analogy to metallic tinkling: this is the *sound of thoracic fluctuation.*

The fact of the existence of this sound was known even to the ancients; it is obtained by a method of exploration, called *Hippocratic succussion*, which the father of medicine describes in the following terms: "After having placed the patient in a solid and steady seat, keep his hands stretched out by an assistant, shake him by the shoulder, and observe on what side the disease produces the sound," (*De Morbis*, II. §45, *ed. Vanderlinden.*) This method had fallen into oblivion, as also the allusion to auscultation scattered amongst the writings of Hippocrates, or, at least, it had been so completely neglected, that Laennec accuses Morgagni of having attempted to prove its uselessness. It was reserved to the author of the stethoscopic science to complete his work by the indication of the resources, which may be derived from succussion.

To obtain thoracic fluctuation, we may follow the same method used by Hippocrates, but it is often quite sufficient to make the patient sit up in bed, and to desire him to move his

body smartly as long as the auscultation continues; or whilst we apply the ear to the thorax, we shake the patient gently by the shoulders.

Characters.—In the physiological state the succussion discloses no sound in the chest; but, in some pathological con-conditions, we perceive the sudden clapping of a liquid in the form of shocks; this sound is perfectly analogous to that caused by shaking briskly a caraffe filled one-third with water. This very singular phenomenon offers, besides, various degrees of intensity and tone, according to the respective proportions of the liquid and air contained in the cavity where it is developed, and according to the force of the concussion imparted to the trunk. It often manifests itself during the spontaneous movements of the patient; and is sometimes so loud as to be heard at a distance; it may even be felt and heard by the patient himself. Laennec transcribed from Boyer the history of a young man, "who, on descending a staircase, heard the sound of fluctuation of the liquid very distinctly in his chest." We have ourselves met with several individuals, who asserted, that they felt very plainly the movements of a fluid in their chest.

Differential diagnosis.—In some individuals, whose stomach is distended with gas, a kind of *clunking* is sometimes heard, when they give themselves a shake after having drunk a certain quantity of water. A similar phenomenon takes place when we shake the body of patients affected with *hydrogastritis*, owing to an obstruction of the pylorus. We may, from want of attention, confound this sound with that of thoracic fluctuation; but the error is easily avoided by examining alternately the thorax and the region of the stomach. By this method we ascertain, that the point, where the sounds originate, differs in the two cases, and that the phenomenon is connected with material conditions, which are indeed analagous, but the seat and value of which are essentially different.

Physical cause.—The sound of thoracic fluctuation (which is easily produced in the dead body), depends evidently on the collision of the liquid molecules against one another; but we cannot precisely determine, in this case, as well as in that of metallic tinkling, what part the air contained in the cavity, and what part the walls, which vibrate at the same time, perform in the production of the sound. We only know for certain, that the phenomenon does not appear, when the cavity

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See Note 2 R

is completely filled with liquid and includes no air, and that it is less evident, when there exists but a small quantity of gas. The pupils of Æsculapius seemed to think, that it might be developed, when the collection was exclusively liquid; they had, however, an obscure notion, that some void was indispensable: "similarly as wine shut up in a bottle produces on agitation a louder sound, the more empty the bottle is," and, indeed, they had observed that "amongst the patients affected with empyema, those who, being shaken by the shoulders, yielded a louder sound, had a smaller quantity of pus in their chest, than those, where the sound was more feeble."—(*Laennec*, T. II. p. 590.)

Pathological signification.—Thoracic fluctuation indicates almost to a certainty the existence of *pneumo-hydrothorax:* but this sign alone, does not inform us whether the gaseous and liquid collection be accompanied by pulmonary perforation, a point, which it is highly important to determine, for the sake of our diagnosis, and above all, for our prognosis. Its value is, therefore, much inferior to that of metallic tinkling, which most frequently accompies it, (vide 108.) The sound of fluctuation might also occur in a *very large pulmonary cavern* half full of liquid; but this is a case of very rare occurrence; only one example of it has come under our observation, and Laennec has noticed it but once: "the two inferior thirds of the right lung, occupied by a large excavation, presented merely a species of cyst, the walls of which, having only the thickness of from one to two lines, adhered throughout to the pleura, which appeared to form in itself, the external portion of the walls of that cavity, over a surface equal to that of the palm of the hand." (*Laennec*, T. II. p. 589.) Facts of this kind are so rare, that we think it scarcely necessary to repeat the considerations previously explained in regard to the differential diagnosis of large caverns, and of hydro-pneumothorax (p. 51 and 108.)

FOURTH ARTICLE.

Auscultation of the Larynx.

In proportion as auscultation is extended towards the superior portion of the air passages, it furnishes a smaller number of phenomena, and fewer facts for semeiology. This explains, why, in comparison with the very numerous and

complete inquiries into the stethoscopic signs of the chest, established by Laennec and his successors, there exist so few observations on those of the trachea and larynx. Previous to the treatise published by one of us (*Archives, Gen. de Med.* July 1838, and June 1839,) we scarcely find any remarks in regard to the application of auscultation to the diagnosis and treatment of diseases of the larynx. Neither Laennec, nor his commentator M. Andral mentions it. M. M. Delaberge and Monneret, in their *Compendium* pass it over in silence, and M. Fournet assures us, that his long continued investigations have only produced a negative result. Stokes (*a Treatise on the Diagnosis and Treatment of Diseases of the Chest*, Dublin, 1837,) has, however, devoted a chapter to this subject, and reported some observations which are not without importance; but neither he nor any other author has sufficiently entered into the subject. We shall endeavor to contribute on our part to the filling up of this gap, by communicating the result of our own experience.

Rules.—In order to examine the larynx and trachea, the patient should be seated on a chair, or lie in bed, placed in the dorsal decubitus on an inclined plane; the head being turned slightly backwards, so as to stretch the parts, should alternately be bent to the opposite side from where the examination is made.

The application of the stethoscope is indispensable. The physician applies it to the lateral portion of the larynx or to the inferior portion of the neck in the substernal fossa; he must take care to press gently lest he occasion pain. In acute diseases, where respiration becomes laborious, auscultation should be performed rapidly; in the opposite circumstances we may proceed more slowly. In all cases we ought to combine the examination of the chest with that of the superior portion of the air tube, because this *indirect* auscultation is at least as useful for our diagnosis as a direct method.

Physiological Phenomena.

In the normal state of the stethoscope placed on the larynx and trachea, transmitted to the ear a descending and ascending murmur, produced by the entrance and exit of the air: this *respiratory sound*, the tone of which is hollow and more cavernous on the larynx, varies, besides, in intensity in different individuals, and especially according to the rapidity and force, with which the air circulates in the air passages. We

have seen, that vocal *resonance* had its maximum also in the larynx, and that the *cough* produces in addition to the concussion, which it imparts to the walls of the tube, an evident sensation of a rapid current of air traversing a hallow space.

Pathological Phenomena.

In some diseases of the larynx, the respiratory murmur of that organ may become more harsh and *grating* (*rapeux.*) Occasionally the alterations of the normal sound are more developed; at one time we hear a more or less acute or prolonged *whistling* sound, or an abrupt and *shrill cry* of a very peculiar character, at another, a sound of *snoring* of variable and sometimes metallic tone; finally, at another a *moist rhonchus with large bubbles* analogous to *cavernous râle.* In some rare cases, the ear perceives a species of vibratory murmur, or *trembling*, as if a moveable membranous flap were agitated by the air. All these modifications, which are commonly permanent, are sometimes remarkable for their intermittence.

Pathological characters and signification.—We must preface, that each of these preceding phenomena, has not always a distinctly developed morbid signification, and that we should not expect to find in the stethoscopic signs of the diseases of the laryngo-tracheal tube, that exactness and precision, which distinguish those of the pulmonary affections. They are, moreover, not very numerous, as we may infer from their rapid enumeration, and are almost never pathognomonic. It was auscultation, which, in the affections of the pulmonary organs furnished the diagnosis with its most positive elements; in these cases the information obtained by means of the stethoscope is only of secondary importance, and the results derived from the examination of functional symptoms should be our chief guide. Let us not, however, undervalue the services, which the application of Laennec's discovery may sometimes render us, in the study of the pathology of the larynx, and let us consider, what indications we may derive from it for semeiology.

The laryngeal respiratory sound is *grating* in the majority of affections of the laryngo-tracheal tube, where the mucous membrane is dry, not so smooth, or variously altered; this character occurs, for example, in the greater number of cases of *acute* or *chronic laryngitis*, with or without stricture of the vocal tube, with or without non-vegetating ulcerations. It is sometimes harsher, when a *tumor* (hyperthrophy of the thy-

roid body, &c.) diminishes, by compression, the diameter of the walls of the organ. By this harsh and almost cavernous blowing, we recognize accurately the exact seat of the larynx, when it is nearly lost in the midst of large tumors. Auscultation, which then determines the true relation of the parts, guides, if we may say so, the hand of the surgeon in the operations he performs on the regions of the neck.

Laryngo-tracheal whistling, differs from the sibilant bronchial râle only in intensity and seat. This intensity is generally in direct proportion to the degree of difficulty of breathing, and to the impediment, which the air encounters in traversing the superior portion of the air passages; it is very frequently so loud, as to be audible at a distance, but sometimes it is less intense, and only discerned by placing the stethoscope on the lateral regions of the neck, or by applying the ear to the thorax, when its resonance marks more or less the vesicular murmur. It accompanies both acts of respiration, and often inspiration alone, where it is always more developed. Its musical tone makes it easily recognized; but it is more difficult to decide in all cases whether the sound be produced in the larynx or in the bronchial tubes; this difficulty is removed by examining alternately on the neck and on the chest: the point where the phenomenon attains its maximum intensity, indicates the centre of its production.

Laryngo-tracheal whistling occurs in spasm of the glottis, whether simple or connected with hysteria, in stridulous laryngitis (pseudo-croup of M. Guersant) in hooping-cough, in œdema of the glottis, in some cases of obstruction of the trachea by foreign bodies, and of its compression by aneurism of the aorta, &c. In the greater part of these diseases it predominates during inspiration; and in œdema of the glottis, the contrast between its intensity during the first act of respiration, and its feebleness during the second, constitutes sometimes an important sign.

In some cases of *laryngeal ulcerations, with tumefaction of their edges*, and with impediment to the current of air, auscultation on the larynx reveals, instead of the sound of whistling, a *sonorous cry*, which is more pronounced in inspiration, and analogous to the sound produced by the air passing rapidly through a narrow orifice. (*Barth, loco cit.* obs. III.)

Dr. Stokes, (*loco cit.* p. 250), mentions another stethoscopic phenomenon, "analogous to the sound produced by the rapid play of a small valve, mingled with that of a bass cord. This râle does not always exist, but, when it does, it bears a dis-

tinct character. It is most conspicuous immediately above the processes of the thyroid cartilage, and disappears in proportion as we examine nearer to the bronchiæ; it is sometimes perceived only on one side of the larynx, as if it corresponded to a circumscribed ulceration."

Laryngeal snoring is to whistling, what the sibilant râle of bronchitis is to the snoring râle: it is but a variety of one and the same musical sound. It depends, moreover, on the vibrations of air in a tube, whose diameter is contracted, and indicates an obstacle to the passage of the elastic fluid, (simple or stridulous laryngitis, ulcerations with swelling of the edges, laryngeal vegetations, &c.) The sound of snoring is sometimes of a well marked *metallic tone*, as if the air resounded in a brass tube: this character seems to belong more exclusively to *croup* than to any other alteration involving a diminution of the diameter of the larynx.

Laryngeal cavernous râle, is produced by the same mechanism as pulmonary cavernous râle: it is owing to the passage of air through mucus accumulated in the larynx. In the agony of death it becomes mingled with *sub-crepitating* râle, produced in the bronchiæ, as also with the rhonchus of the trachea, and constitutes the râle of the dying, (tracheal râle of Laennec). It combines, likewise, with the snoring sound of *stertorous respiration*.—" Laryngeal, or tracheal rhonchus," says M. Piorry, (*Traité de Diagnosis*, T. I. p. 417), "indicates with certainty the presence of liquids in the larynx. When it is very loud, and characterized by large bubbles, it implies that the respiratory powers are still vigorous, but that there is an abundance of liquid. . . . . . It always indicates a certain amount of danger, corresponding to the facility, with which the liquids are rejected, and to the disappearance, more or less complete, of these sounds after the cough and expectoration. If, after these acts, it cease rapidly and completely, life is not in imminent danger; if it persist after the completion of these acts, we have every thing to fear, for suffocation is close at hand."

In some diseases of the larynx, the laryngo-cavernous râle is confined to the superior portion of the vocal tube, and is then not without importance to diagnosis. Accordingly, in several cases of *hemoptysis*, auscultation, by manifesting the existence of *moist râle* in the larynx, without rhonchus in the chest, or in the inferior portion of the trachea, informs us that the hemorrhage has its source in the larynx itself, (*Piorry, ibid*, p. 444).

In the case of ulcerations in the larynx, the presence of *cavernous râle*, at a certain point of the organ, determines more precisely the seat of the ulcers, and the maximum intensity of the râle indicates the side, where they are most numerous, and where the ulceration is most advanced. This is especially the case, when the ulcerations occupy the inner part of the ventricles. In some cases of the presence of *foreign bodies* in the larynx or trachea, direct auscultation reveals the point, where the body is arrested: immediately after its introduction into the air tube, it gives rise to a variable sound of whistling, and, if it remain there for some time, it induces a local irritation, with secretion of mucous, and consequently the manifestation of *cavernous râle*, (*Stokes*, *loco cit.* p. 285). A moist rhonchus may be, in the same manner, produced in the larynx, subsequent to the rupture of an aneurism of the aorta into the air passages, (*Piorry*, *loco cit.* p. 428).

The *trembling*, of which we have spoken indicates infallibly the existence of *croup* with floating false membranes; and, if it were confined to the larynx, it would be rather a favorable sign, because it announces the presence of non-adherent plastic concretions, susceptible of being rejected by expectoration; if, on the other hand, auscultation show, that this *trembling* extends throughout the course of the trachea and bronchial tubes, the diagnosis is unfavorable, and we are to conclude, that the false membranes occupy a large surface of the air-tube (*Barth*, *loco cit.* obs. VI).*

Semeiological value.—We have just seen, that very few diseases of the larynx are interpreted by special acoustic signs; the most different alterations give rise to the same effect, viz: to mechanical obstruction of the air-tube,—whence it follows, that similar phenomena are the signs of different lesions, such as induration, thickening of the mucous membrane, and of the sub-mucous cellular tissue, vegetating ulcerations, syphilitic excrescences, tumors, cancerous or otherwise, pseudo-membranes, polypi, and foreign bodies. The signs we have passed in review have therefore no great value in themselves, but they become of more considerable importance by the combination, and comparative study of several characters, such as the intensity of the phenomenon, its more or less musical tone, its seat, its degree of stability or mobility, and finally, by the simultaneous auscultation of the chest.

*See Note 2 S

Accordingly the laryngeal abnormal sound, caused by obstruction of the air passages, and perceptible at a distance, or by means of the stethoscope, is much more intensely developed as the obstructing body is carried upwards: in its lowest position a *grating* laryngeal sound is only produced; in the higher, stridulous sounds of a more or less musical tone are formed (blowing, snoring, &c.) The auscultation of the laryngo-tracheal tube, by precisely determining the point, which corresponds to the maximum of the morbid sound, informs us occasionally, whether the obstacle occur at the superior portion of the canal, and be owing to an obstruction of the larynx, or whether it depend on compression exercised on its inferior portion by a tumor, for example, by aneurism of the aorta, &c.: the ear may then judge with accuracy, that, in the first case, the sound is produced in the larynx itself, and that in the second, it originates at some distance, and comes from the inferior extremity of the trachea.

Fixed and permanent sounds indicate a fixed disease, which produces constantly the same mechanical effect, such as œdema of the glottis, vegetations of the mucous membrane, &c.; on the other hand, the intermittence of the acoustic phenomena, indicates a spasmodic or intermittent affection. If the sounds shift or disappear for a moment, we may infer the existence of a moveable obstacle, for instance, a foreign body in the air passages.

We have alleged that the signs obtained from the auscultation of the larynx, acquire a greater value by their combination with those derived from a comparative examination of the chest. Indeed, there exists a *thoracic* phenomenon common to a great number of diseases of the vocal organ, viz: the *diminution of vesicular murmur*,—a diminution, which is in direct ratio with that of the lesion: every alteration, which occasions a considerable obstacle to the introduction of the air into the air passages, either by obstructing or contracting the diameter of the canals, (swelling, inflammation, vegetations, accidental products, &c.) or by compressing them from without, (cancerous tumors, cysts, aneurisms, &c.) or finally, by producing the more or less complete occlusion of the superior orifice of the air-tube, (hypertrophy of the tonsils, polypus in the nasal fossa, falling back upon the superior portion of the larynx); all these lesions cause in the chest a diminution of the respiratory sound, which may terminate in complete silence.

From the knowledge of this fact, so useful to diagnosis, we

naturally regard it as a fixed rule, always to examine the thorax in affections of the larynx. Indeed, if in a disease of the neck, we recognise feebleness of vesicular murmur without any sign of thoracic disease, capable of producing it, (extensive double emphysema, &c.), we conclude, that the affection is accompanied by an obstacle to the admission of the air into the air passages; and this indirect sign becomes the more valuable, as several of the above-mentioned alterations cannot be directly recognized by the eye and the touch, for example, œdema, which may exist in the glottis, without our being able to ascertain with the finger any tumefaction at the superior portion of the larynx.

The results of this comparative examination, serve also to establish the different diagnosis, between spasmodic suffocation and asphyxia caused by a foreign body: in the former case, (spasm of the air passages,) the vesicular murmur is not annihilated in the chest, at least for any length of time, whilst in the latter (a mechanical and permanent obstacle to the current of the air) the pulmonary respiratory sound continues to be feeble or absent, notwithstanding the energetic efforts made to dilate the thorax. We foresee the consequences which ensue from those different results, as regards surgical treatment.

By keeping in mind the possibility of this diminution of the respiratory sound in the thorax, owing to obstacles in the larynx, we shall, in other circumstances, be on our guard against the sad blunder, which mistakes this silence of the vesicular murmur for a sign of emphysema of the lung, whilst the disease in the larynx would remain unnoticed. The physician, by recollecting, on the other hand, that a sound of whistling may be produced in the larynx, and resound as far as the interior of the chest, will, on hearing this abnormal sound, carefully inquire in what point it originates; and the just determination of the seat of the phenomenon will likewise enable him to avoid errors.

The comparative examination furnishes besides useful indications, in some cases where *foreign bodies* obstruct the air passages: it may indeed happen, that the obstacles to the passage of the air is moveable, and that consequently the laryngeal whistling, which indicates a mechanical obstruction, shows itself only at intervals, or disappears even entirely; by means of auscultation of the chest, we may then ascertain the true situation of the foreign body: it is arrested in the trachea, if the respiratory should be feeble on both sides, or

it is located in a large bronchia, if the vesicular murmur have ceased on one side only. And in the same way as we may trace the displacement of the foreign body in the air passages, we may also decide whether it be definitely fixed in some point of the chest, and whether it have caused by its presence some serious lesion of the parenchyma, judging by the appearance of certain stethoscopic phenomena, circumscribed at a region, where the stethoscope had previously revealed no morbid condition.

But this is not all, the examination of the chest throws light on the *nature* of the diseases of the larynx, by the discovery of concomitant signs in the lungs. If, for example, a grating or stridulous sound, coinciding with symptoms of laryngeal phthisis, lead us to establish the presence of ulcerations in the larynx, and if at the same time the auscultation of the thorax reveal signs of pulmonary tubercles, we conclude, that these ulcerations are of a tuberculous nature. In some cases of œdema of the glottis, the same examination disclosing the presence of tubercles of the lung, leads us to suspect, that the œdematous swelling has been developed round a tuberculous ulceration, and that it is not purely inflammatory.

In conclusion, auscultation of the chest should always be performed in affections of the larynx and trachea, in order to ascertain, whether there exist pulmonary *complications.* Accordingly, in croup, and in simple laryngitis, we should inquire whether any inflammation in the mucous membrane of the bronchiæ and especially in the parenchyma of the lung, exist at the same time. It is true, that in laryngeal affections, where the obstacle to the introduction of the air occasions a very loud stridulous sound, the diagnosis of the diseases of the chest becomes very difficult, because this sound of snoring may completely obscure the vesicular murmur, or because the quantity of air admitted into the air passages is not sufficient for the production of vesicular or bronchial râle; fortunately percussion, the results of which are not modified by the same cause, assists the physician in the diagnosis of these cases.

We may easily form an estimate of the importance, in so far as the treatment is concerned, of the results obtained by this double auscultation. On the one hand, we shall not abandon a patient, whom we might have supposed to labor under pulmonary emphysema, to die of a laryngeal affection, and, on the other hand, we shall not uselessly perform trach-

eotomy on a patient threatened with suffocation, from purely spasmodic angina, or, in desperate cases, on individuals, where the alteration of the larynx is complicated with pulmonary diseases of a fatal character.

CHAPTER II.

AUSCULTATION OF THE ORGANS OF CIRCULATION.

Auscultation of the *circulatory apparatus* is divided into two distinct branches, which ought to be separately studied, viz: Auscultation of the *heart*, and auscultation of the *large vessels*.

Art. I.—Auscultation of the Heart.

We may adopt the same arrangement in the subdivisions of this article, as in those of the pulmonary apparatus: After having discussed several important *regulations* we shall proceed to the explanation of the *physiological* phenomena furnished by the auscultation of the heart, and, in conclusion, give a description of the *pathological* phenomena.

§ 1. *Important Regulations.*

In order that the observer may form a correct idea of the results derived from auscultation, it is necessary, in the first place, that the *patient* remain perfectly at rest, lest any artificial disturbance in the circulation be productive of error. In some cases, on the contrary, we ought to induce an acceleration in the movements of the heart, with the view of rendering more perceptible abnormal sounds that were previously less distinctly heard. Accordingly, we direct those patients, who seem to labor under an affection of the heart, to walk rapidly, for the circulation thus accelerated, develops or exaggerates phenomena, which would not otherwise have existed, or would have escaped our notice.

The person to be examined should generally be recumbent, but as it is often very painful to continue in the horizontal posture (as in the case of dyspnœa), the trunk and the head ought to be supported on an inclined plane: Some patients

are under the necessity of being in the sitting posture. It is often useful to examine them, first lying and then sitting up, in order to ascertain, whether these different positions, give rise to variations in the acoustic phenomena. In certain effusions into the pericardium for example, we hear a sound of of blowing, when the individual is recumbent, which disappears when he is sitting up. The cause of this is undoubtedly the displacement of a liquid, which from compressing, in the first instance, the origin of the large vessels, descends, in the upright posture, to the inferior portion of the pericardium. If we wish to examine the heart from the back, M. Piorry recommends, that the patient should be seated in a reclining attitude, so as to bring the organ nearer to the posterior walls of the thorax.

The precordial region should only be covered with a shirt, or what is much better, left bare, as it facilitates the exact determination of the situation of the stethoscopic signs, as well as their connection with the seat of other visible phenomena (vaulted figure of the chest, shock of the apex of the heart, &c.) for a comparison of this kind may be of value to diagnosis.

Respiratory murmur does not generally prevent the sounds of the heart from being heard: But if the ear be not sufficiently familiar with the phenomena of auscultation, or if the normal or abnormal sounds be too feeble and indistinct, the patient should be desired to breathe as gently as possible, or even to suspend respiration for an instant; the ear will then much more easily catch the sounds peculiar to the central organs of circulation. This suspension should of course not be protracted so long as to disturb the motions and sounds of the heart.

The physician ought to choose the same convenient attitude as in the auscultation of the respiratory organs; if he employ the stethoscope, he should stand on the left side; but if he examine with the ear, he will sometimes find it preferable to stand on the right side of the patient.

Are we to employ mediate to the exclusion of immediate auscultation, or *vice versa?* The precepts laid down in the first section of our work, are here again applicable, but with some restrictions. In general, we may choose indifferently, either the one method or the other. The sound of grating (bruit de râpe), however, (and, indeed, every friction sound), is more easily appreciated by the ear, because a tactile sensation is superadded to the acoustic phenomenon. The mere circumstance of the stethoscope covering a very small area,

gives it a decided advantage, as it assists more readily in determining the exact seat of the sound, as well as its limits, and the point, where it reaches its maximum intensity. We are thus enabled to decide, whether the disease have established itself in the right heart, or in the left; in the mitral or aortic valves, &c. Laennec, and several of his successors, give a preference to the cylinder mounted with its disk. This precaution is not without its advantage, if we desire to appreciate the impulse of the heart, because the solid instrument communicates more freely the movements, which the organ imparts to the thorax; yet, in our own estimation, the sounds appear not so remarkably modified as to persuade us to any alteration in the form of the stethoscope.

The observer should not confine himself to the examination of the centre of the precordial region. He ought to explore beyond the ordinary limits assigned to that region, with the view of including an area of larger radius. There are, indeed, cases, where the stethoscopic signs, as well as the heart itself, surpass the outlines traced by pathologists; for sometimes the pulsations are heard more to the right side, because an effusion into the cavity of the left pleura pushes the organ behind the sternum; sometimes, on the contrary, the heart is protruded towards the left, or attached on that side by morbid adhesions; accordingly, we often perceive sounds just above the nipple, which remain inaudible at the precordial region. Moreover, it becomes occasionally necessary, as we shall see in the sequel, to examine the sonorous phenomena over the whole surface of the chest, in order to appreciate their relative intensity at the different points of the thorax.

In this investigation, it should be our study to arrive at a clear distinction of the sounds of the circulatory system, from those belonging to the respiratory apparatus, lest we mistake, for example, a friction sound of the pleura for a friction sound of the pericardium. This precept holds good, even when we have to examine in front at the precordial region; for the heart being often overlapped by a lobe of lung, it requires great nicety to isolate its appropriate sounds from among those of respiration. After this, we should consider them in their different points of view, and examine, successively, their rhythm, character, and pathological modifications. An analysis of this kind, however, is not always easy; the observer should likewise protract the examination to convince himself of the accuracy of his perceptions, and should repeat his researches several times and at different intervals, to assure

himself whether the acoustic phenomenon be permanent or temporary.

We insist on the rigorous observation of such precepts, because these phenomena are more difficult to perceive, than those of the respiratory apparatus; they are, besides, less numerous, and their morbid signification less distinct; we should, therefore, give our most serious attention to the investigation of them. We shall thus procure, from the auscultation of the heart, results, which are certainly less positive, than those derived from the auscultation of the respiratory apparatus; but which are, nevertheless, of equal relative value. For this admirable discovery has now enabled us to *recognise* diseases, whilst formerly they were merely *guessed* at. But we repeat, that we must summon up all our attention, and that the neglect of the above regulatious has occasionally involved the observer in the most pernicious errors, which are certainly not to be imputed to the method of auscultation, but to its false application: (*non crim en artis*, *quod professoris est.*)

Far be it, however, from us to say, that the science, created by Laennec, is now complete, and that it could not be enriched by new discoveries. The very important illustrations added to it by the meritorious labors of MM. Bouillaud, Hope, &c., insure its future progress. Let us then turn to the best account the resources it now offers, and let us hope to accumulate more treasures for the future by profiting wisely from what we have at present.

Whatever the value of auscultation may be, the observer ought not to confine himself exclusively to its data, nor should he form a positive opinion before having added to the results of stethoscopy, other valuable materials derived from the various methods of physical analysis; and, above all, from a complete comparative examination of the local and general symptoms. If the usefulness of such a comparison be incontestible in pulmonary affections, it is much more so in diseases of the heart: the physician is surrounded with too many uncertainties and difficulties of investigation, to content himself with the exclusive support of a single method, and he cannot collect too much light to pierce the clouds of darkness which encircle the diagnosis.

§ II. Physiological Phenomena.

Sounds of the Heart.

When, in the normal state, we apply the ear to the precordial region, we hear a species of *tic-tac*, formed of two successive sounds, the one dull and the other sharp, which are repeated in the same order from 60 to 80 times in a minute, differing slightly in power and character.

The *first* of these sounds is dull, deep, and more prolonged than the second; it coincides with the shock of the apex of the heart against the thorax, immediately precedes the radial pulse,* and has its maximum intensity between the 4th and 5th rib, below and a little to the outside of the nipple, or rather about an inch above the point, where the summit of the heart strikes against the wall of the thorax. From its tone and seat it has received the term, *dull or inferior sound.* The *second* sound, likewise called *sharp or superior sound*, is clearer, shorter, and more superficial; it is produced after the pulsation of the arteries, and its maximum intensity occurs nearly on a level with the 3d rib, a little above and to the right of the nipple, towards the left edge of the sternum.—Some authors maintain, that the sound of the *right* heart resounds more clearly at the inferior portion of the sternum, and that the sound of the *left* cavities is more distinctly heard on a level with the cartilages of the ribs; but it is impossible to distinguish them from one another, in the normal state, for they are intimately united, and convey to the ear one uniform sensation.

The sounds of the heart, as regards their coincidence and *rhythm*, are repeated in couples, in the following order and relation: In the first place, a dull sound, coinciding with the shock of the heart, then a very short interval, (short pause), filled up by the pulsations of the arteries; next to this, a sharp sound, and, in conclusion a long rest, (*long pause*). Each couple, with its intermediate pauses, constitutes a *beat* or rhythm, and an arterial pulsation corresponds to each beat. Hence results a species of triple measure, of which the first sound occupies about a third, the short pause nearly a sixth, the second sound a sixth, and the long pause a third.

The pulsations of the heart succeed one another more or less rapidly, and their *frequency* is dependent on sex, age,

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*See Note 2 T.

part contains, and being encumbered with useless details, it would be valuable to students. As it is, we are candidly of opinion that the entire value of the work consists in the details to which we have referred, while much of the remainder, which goes to make up the work will prove either useless or positively detrimental.

The illustrations of the work are defective. Many of the wood-cuts are not well calculated to illustrate the subject, while the colored engravings are too few to be of any particular value.

Finally, we have endeavored in our remarks, to avoid injustice to the excellent and intelligent author, while at the same time we have felt it a duty to expose what were deemed most glaring defects. This, we hope, has been done in a proper spirit and with just motives. We trust the work may enter extensively into the hands of the profession, and that they will bestow on it careful consideration.

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Art. VIII.—*An Introductory Lecture*, delivered by Gunning S. Bedford, M.D., Professor of Midwifery and the Diseases of Women and Children, in the New York University. pp. 18. November, 1845.

This address is introductory to the author's course of obstetrics, and abounds in useful precepts for their further guidance. Dr. Bedford speaks decidedly in relation to the improper employment of obstetrical instruments, and details a case of a revolting character, exhibiting the most gross and culpable ignorance and rashness on the part of the medical attendants.

We think the *style* of the Lecture is objectionable—it is a little too familiar, appearing half professional and half popular, although it was doubtless delivered to the medical class. The Lecture, however, contains much that would prove useful to pupils, and is, upon the whole, creditable to the reputation of the author.

PART III.

AMERICAN SUMMARY.

1. *Case of Ligature of the Left Subclavian Artery within the Scalenus Muscle, for Aneurism.* By J. Kearney Rogers, M.D. (*N. York Journal of Med.*, March, 1846.) Although this case proved unsuccessful, yet the result convinced Dr. Rogers that the operations is practicable and proper. On dissection it was found that the ligature had passed through the coats of the artery; that the stump of the subclavian was filled with a firm coagulum, which was adherent to its inner coat for three quarters of an inch. The hemorrhage proceded from the distal end of the artery, and, Dr. Rogers is of opinion, came from the vertebral artery, which he thinks should be secured before the operation. He thinks it possible, however, that the thyroid axis may have furnished a part of the blood. The operation was performed in the following manner:

The patient was laid on a low bed, with his head and shoulders raised, and his face turned to the right side. The light from the dome shone directly on the part to be operated on.

An incision was made three inches and a half in length on the inner edge of the mastoid, terminating at the sternum, and dividing the integuments and platysma myoides. This was met by another extending to the sternal extremity of the clavicle, about two and a half inches. This last incision divided a plexus of varicose veins passing in the integuments, covering the clavicle to the subclavian. Free bleeding taking place from their cut and patulous extremities, it became necessary to check it by ligature.

The flap of integuments and platysma myoides was now dissected up, and the lower end of the mastoid laid bare; a director was passed under this muscle, and the sternal portion and half of the clavicular divided by the bistoury. This muscle was now turned up, and the sterno-hyoideus muscle, the omo-hyoideus, and the deep-seated jugular vein were seen covered by the fascia.

On turning up the mastoid, a portion of the aneurismal sac strongly pulsating was brought into view, overlapping about half the width of the scalenus, forming now the outer part of the track through which I was to pass, showing fearfully one of the dangers of the operation, which, from my previous examinations of the part, I had of course anticipated.

The fascia being divided by the handle of the scalpel and the fingers, I passed in contact with the deep jugular on its outer side to the inner edge of the scalenus anticus, intending, for the purpose of avoiding as much as possible all danger to the thoracic duct, to reach this muscle fully half an inch above the rib, rather than at its insertion. I now felt distinctly the phrenic nerve running down on the anterior surface of the scalenus, and was confident that I should be able to avoid any injury to it. Having attained the inner edge of the scalenus, by pressing downwards with the finger, I soon discovered the rib, and after some little search easily found the subclavian artery. By pressing it against the rib, all pulsation ceased in the tumor, and by removing the finger, pulsation returned.

I now felt that great care was necessary to detach the artery, and avoid danger to the pleura and thoracic duct. In accomplishing this part of the operation, I at first tried Sir Philip Crampton's instrument, but ascertaining that I could better carry the ligature around the artery and bring up its end, by the invention of Drs. Parrish, Hewson, and Hartsborne, of Philadelphia (long since given to the profession by them, and lately claimed by Mr. L'Estrange of Dublin), I accordingly adopted that instrument.

This part of the operation, as will be imagined, was not very readily accomplished. The great depth of the vessel (nearly the length of my forefinger), and narrowness of the wound, prevented a very easy management of instruments. The point was introduced under the artery, and soon directed upwards so as to avoid injury to the pleura. The needle carrying the ligature was now detached from the shaft of the instrument, and drawn upwards so as to include the artery. I readily tied the ligature, and tightened it with the forefinger in the bottom of the wound. All pulsation immediately ceased in the aneurism and the arteries of the extremity,

The patient complained of no pain or unusual feeling in the head, as might have been expected from so suddenly changing the current of so large a quantity of blood.

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2. *Cases of Remittent Fever which occurred in the Baltimore Almshouse and Infirmary.* (*Am. Jour. Med. Science*, April, 1846.) The results of these cases have been reported by Drs. Anderson and Frick, Resident Physicians. The *post mortem* examinations revealed the following conditions:

Brain.—This organ was examined in seven out of the ten cases, and in *all* of them, either its membranes or its substance was injected, and in two of them there was moderate effusion in the cavity of the arachnoid.

Lungs.—In one-half of the cases, the lungs are described as healthy, and in the other half there was more or less intense redness of the bronchia, and, in one case, of the larynx. But this condition does not seem to have been accompanied with cough during life, and its inflammatory nature may therefore well be doubted.

Heart.—The heart was examined in nine cases, and in *all* of them its muscular tissue was found to be more or less *softened.* The only one in which this condition was not remarkable, also presented large fibrinous concretions in both ventricles. The patient had been "very delirious," and some portions of his pia mater were found "infiltrated with a turbid milky serum."

Stomach and Intestines. — The stomach generally contained from two to four ounces of a dirty yellow fluid. The mucous membrane was found to be injected in seven out of nine cases in which it was examined, and in three of them intensely so. In five cases it was softened near the cardiac extremity, and in four near the pylorus, where also it was for the most part grayish, thickened and mammillated. In every instance Brunner's glands were unusually developed, and in three cases to a remarkable degree. The glands of Peyer were constantly healthy, but generally visible.

Spleen.—In *all* the cases, without exception, the spleen was very much enlarged, being from two to six times larger than natural. In one instance it weighed three pounds. In nine out of ten cases it was very soft or pulpy, and of a bluish black color.

Liver.—The size of the liver was noted in nine cases, in all of which it was unnaturally large. Its consistence was very much diminished in ten cases, in eight of which the right lobe was the principal seat of the alteration; in one the left lobe was chiefly affected, and in the remaining one the whole organ was softened. In *all*, the color of the liver was either bronzed, or like that of slate; the surface of a section was polished or shining; and in every instance but one, the different colors of its component parts could not be distinguished. In seven out of eight cases in which the state of the *gall-bladder* was recorded, this receptacle was *distended* with thick grumous bile, resembling molasses. In the eighth case it was moderately distended with straw-colored bile.

From this summary we may now conclude that the cases of remittent fever under examination presented the following lesions uniformly; to-wit: 1st. Congestion of the brain; 2d. Softening of the heart; 3d. Softening of the mucous membrane of the stomach; 4th. Softening of the spleen, with enlargement; 5th. Softening of the liver, with enlargement, and a bronzed or slate-like hue of that organ, and distension of the gall-bladder with inspissated bile.

idiosyncrasy, and even on the position of the body. In adults they are generally from 60 to 80 per minute; but, in some individuals, they exceed these limits more or less, (owing, probably to a particular bodily constitution). They are also more accelerated in women, and much more so in children. Accidental causes, such as bodily exercise, moral emotion, &c. have the same effect, and occasionally alter their rhythm, whilst the contrary effect of retardation has been remarked only in a very few cases.*

The *intensity* of the sounds, which, in the normal state, is of moderate degree, becomes modified by several external or internal causes: The sounds are louder in nervous persons with a narrow and lean chest, than in those of an opposite condition; they increase, also, in intensity, when any cause accelerates for a moment the circulation, and their intensity stands (caeteris paribus) in direct proportion to the energy and rapidity of the contractions of the heart. This intensity varies, also, with the posture of the body. Accordingly, the *first* sound is more clearly heard, if the body be inclined forwards, because a greater surface of the heart comes in contact with the walls of the thorax, and it is weaker in the opposite posture.

The normal sounds have their maximum at the precordial region, whence they propagate with a gradual decrease of the intensity over a *space*, which changes with different physical conditions: They are distinctly heard in an adult of mean corpulence at the region of the heart, and then decrease gradually in proportion as we depart from this centre; they are likewise pretty distinctly perceived in front, at the right side; but less distinctly from behind on the left, and scarcely on the right side. Being circumscribed by narrower limits in fat persons with a large chest, they transgress these limits in lean persons with a small chest, and are heard pretty clearly from behind at the right side.

The same accidental causes, which increase the intensity of the sounds, equally influence their propagation; and pathological conditions, which exist external to the heart in the surrounding organs, produce a similar effect. These sounds are more circumscribed and dull in persons affected with emphysema, in consequence of the air being a bad conductor of sound, but they are, on the other hand, louder, and propagate farther in consumptive persons, whose lungs are indurated by tubercles, and therefore better conductors.

*See Note 2 U.

The above mentioned physiological conditions, or other accidental causes, such as repose or agitation, fullness or vacuity of the stomach, etc., modify likewise, the *character* and tone of the sounds. They are more acute in youth, somewhat duller in old persons, and in some cases of distended stomach, the change in tone becomes very conspicuous, and verges on metallic sound. But in the normal state, the sounds are pure, whatever their tone may be, and free from harshness or grating.

We lay great stress on the distinction of all these varieties of sounds, which are peculiar to the heart in its physiological state. It is of consequence to know them, if we wish to avoid great mistakes. And really, without this preliminary knowledge, with which the study of pathological modifications should always commence, we would constantly be in jeopardy of committing the most pernicious and fatal blunders. At one time, for example, we would attribute to eccentric hypertrophy, those loud palpitations, which a tuberculous lung propagates to the ear; at another, we would overlook a real hypertrophy in a person affected with emphysema, if the sounds of the heart, badly conducted by the light portion of lung, which overleaps the organ, were but feebly perceived over a small space.

Theory of the Sounds of the Heart.

By what mysterious mechanism are sounds produced in the central organ of circulation? This question has strongly excited the curiosity of pathologists, and brought into play all the resources of their imagination. So many works have been published on this subject, that science is really encumbered by them, and that, through the mist of opposite theories and contradictory facts, the observer is scarcely regaled by a single beam of truth. In order to wind our way through this labyrinth, let us commence with a historical account of the opinions of the various authors, and shortly point out, what seems to us materially wrong in their systems. Let us then advert to such positive experiments, without which it would be very imprudent to draw a conclusion; and let us finally discuss the most probable causes of those sounds, in the confidence, that though we may not have succeeded in the entire solution of this very difficult and intricate problem, we have at least approached the truth as near as possible.

Laennec (T. iii. p. 29,) admits, that the sounds of the heart are produced by alternate contractions of different portions of the organ. He says, "In the normal state, we perceive two successive sounds; *the one* is sharp and abrupt, analogous to the clapping of the valve in a pair of bellows, it corresponds with the systole of the auricles; the other, more dull and prolonged, coincides with the beat of the pulse and with the sensation of the shock, and indicates the contraction of the ventricles." Hence it follows, that according to Laennec, the *first* or dull sound, is owing to the contraction of the ventricles; and the *second* or sharp sound, to that of the auricles.

This view, supported by the authority of an illustrious name, was received for a long time, without farther investigation; but the explanation of the second sound is not tenable. If it were so, the contraction of the auricles ought to *succeed* that of the ventricles. Now, it is proved by experiment, that it *precedes* that of the ventricular cavities, and that the two sounds continue to be heard, even after the auricles cease to contract.

Mr. Turner, (*Med. Chir. Transact.* Edin. T. III.), restoring the order of succession in the motions of the heart, as it was first established by Haller, Harvey, &c., admits the theory of Laennec for the first sound, but rejects it for the second, which he attributes to the falling back of the heart upon the pericardium during ventricular diastole. Mr. Turner is in the same predicament as Laennec, for the second sound continues to be heard, as we shall see in the sequel, when the heart contracts out of the pericardium.

According to Dr. Corrigan, (*Transact. of Coll. of Physicians of Ireland*), the first sound, as well as the impulse of the heart, are owing to the blood rushing into the ventricles, in consequence of the contraction of the auricles, and the second to the collision of the internal surfaces of the ventricle during its systole, which he supposes to be instantaneous. In regard to the first sound, it is proved by experiment, that it coincides, as well as the shock of the heart, with the systole of the ventricles; and, if the explanation of the second sound were correct, the pulse ought to be synchronous with it, or rather to succeed it, whereas the contrary takes place.

Some experiments, performed on living animals, have led M. Marc d'Espine, (Arch. gen. de Med. xxvi, p. 427), to the following conclusions: 1st. The first sound is heard, whilst the ventricles, in the act of contracting, strike *with their apex against the thorax*, and propel the blood into the aorta and

pulmonary artery. 2d. The short pause preceding the first sound, takes place during the short interval of rest, and occurs immediately after the contraction of the ventricles. 3d. The second sound is heard during the double phenomenon of contraction of the auricles and dilatation of the ventricles, that is, during the passage of the blood from the auricles into the ventricles. 4th. The long pause, which takes place after the second sound, coincides with the long interval of repose, which the heart allows itself after completing the cyclus of its various functions.

M. Marc d'Espine, proceeding to inquire into the causes, admits, "that of all the phenomena displayed during the first sound, the *contraction of the ventricles* accounts most satisfactorily for this first sound; and of the phenomena coincident with the second sound, the *dilatation of the ventricles*, is that, which explains it most satisfactorily. Suppose M. d'Espine to be correct in regard to the first sound, he is far from being so as regards the second, since we are informed, by positive experiment, that the second sound ceases, or is reproduced by suspending or restoring the efficacy of other conditions than ventricular dilatation. (*See afterwards Exp. de C. Williams.*)

M. Pigeaux (*Thèses de la Faculté, February*, 1832. *No.* 24, p. 6, &c.), was the first, who recognised the blood as the immediate agent in the production of the sounds. He maintained, that the collision of the blood with the walls of the vessels, which it traverses, produces a sonorous vibration, and that the contractions of the cavities of the heart are but an indirect cause of the phenomenon. "The fluid, being propelled into the ventricles by an aphonous contraction of the auricles, strikes or rubs against their compact walls, which, being put into a state of vibration, give rise to the first sound; again, the second sound is the result of the collision of the blood with the walls of the aorta and pulmonary artery." But we have already objected, that the first sound coincides with contraction of the ventricles, and with the impulse of the heart; and if the second were the result of the shock of the blood against the walls of the aorta and pulmonary artery, the pulse ought to succeed the second sound, whereas it precedes it.

The hypothesis of M. Pigeaux could not withstand these objections, and he himself modified it in a recent work (*Traité des Maladies du Cœur*, 1839). In his first theory the motion of the heart *begins with the contraction of the auricles*, which, projecting the blood against the ventricular walls, occasion

the first sound; then follows the contraction of the ventricles, corresponding to the short pause; and, finally, the second sound, produced by the collision of the blood with the arterial walls, the whole to conclude with the long pause. In his new theory it is otherwise: "Let us suppose for a moment," says the author, "the heart to be entirely empty, the blood flows towards it from all quarters, and in a current, rendered continuous by the incessant discharge of blood into it from the veins. This fluid penetrates into the auricles, and finding the auriculo-ventricular valves relaxed, descends by its own weight into the ventricles, thus causing their distention. The heart now being full, let us see what happens: *The auricles are not the first in contracting*, for, as the ventricles are already filled, there would be no design in such a movement. *The ventricles contract, therefore, instantaneously;* the blood compressed from all sides rushes against the auriculo-ventricular and sygmoid valves, and as these latter are the only surmountable obstacle, it precipitates itself through their orifices and propels the blood of the arteries. . . . . . *Immediately after the contraction of the ventricles the auricles contract in their turn*, and drive the blood into the nearly empty ventricles, which we know to be then close to the walls of the thorax. . . . After these two successive contractions follows the long interval of repose of the whole organ."

We perceive, according to this new theory, that the movements of the heart proceed in an order, the very reverse of what M. Pigeaux had first assigned to them. We are far from blaming the author for having renounced one opinion and preferred another, provided it be a change for the better. But is this really the case? What ground has this observer for affirming that, contrary to irrefutable experiments, the contraction of the auricles succeeds that of the ventricles? We cannot approve of altering the order of succession in the movements of the heart; and we think that M. Pigeaux has rejected one opinion in accordance with established facts, to adopt another, which is completely at variance with them.

Has he succeeded better in the explanation of the sounds? Let us attend to what he says, "The first sound, contraction of the ventricles, dull or inferior sound is produced by the friction of the blood against the walls of the ventricles, the orifices, and the walls of the large vessels; 2d. the second sound, contraction of the auricles, sharp or superior sound, results from the friction of the blood against the walls of the auricles, the auriculo-ventricular orifices, and the cavity of the

ventricles; 3d. long pause, the blood continues to distend the auricles and ventricles; this fluid enters them silently from not being sufficiently propelled.

We perceive, that as far as the motions and sounds are concerned, M. Pigeaux has chosen a theory the very reverse of his original opinions; the first sound, which he attributed formerly to the collision of the blood with the ventricular walls, and which he called on that account inferior, is now attributed to the friction of the blood against the ventricular walls, the orifices, and the *walls of the large vessels:* again, the second sound, which he termed superior, and explained by the collision of the blood with the walls of the large vessels, is now said to be produced by the friction of the blood against the walls of the auricles, the auriculo-ventricular orifices, and the *cavities of the ventricles.*

This modification has indeed the advantage of re-establishing the coincidence of the first sound with the systole. But we can hardly conceive, how the friction of the blood against the arterial orifices, and the *walls of the large vessels*, could materially contribute to the production of the *inferior sound*, which has its maximum near the apex of the heart; and how the collision of the fluid with the *ventricular walls* could have a share in the production of the *superior sound*, which has its maximum at the insertion of the large vessels. In short, it appears to us, that our worthy colleague, M. Pigeaux, has deceived himself by his attempted amendments. According to his first view, his theory of the succession in the motions of the heart is correct, and that of the sounds radically wrong. According to his second view, the theory of the motions is radically wrong, and that of the sounds far from being correct.

Dr. Hope (*Treatise on the Diseases of the Heart and large Blood Vessels*, 1831,) performed some very interesting experiments on asses, the heart of which was laid bare and examined by the eye, the touch, and the ear. He convinced himself, that the auricles are the first in contracting, and this without any appreciable noise; that forthwith the contraction of the ventricles takes place, coinciding with the shock of the heart against the thorax; and then follows the interval of repose. The first sound is synchronous with the contraction of the ventricles, and the second with their dilatation; both are produced by the reciprocal collision of the molecules of the fluid.

Dr. Hope, having repeated the inquiry into this intricate question with more accuracy, expresses a much less exclusive

opinion in a second edition (*London*, 1839.) He admits, that the origin of the sounds is of a complex character, and that they result from the concourse of several circumstances.—The first sound might be a compound: 1st. of the extension-sound of the mitral and tricuspid valves; 2d. of the muscular sound (*muscular extension*) caused by the brisk and sudden tension of the ventricular walls at the moment of commencing systole; 3d. of the rotatory sound resulting from the fibrous contraction of the fleshy walls, which may prolong, and, perhaps, reinforce the sounds of the heart. The second sound might depend on the sudden tension of the semi-lunar valves, owing to the reflux of the columns of blood in the aorta and pulmonary artery.

Dr. Carswell, (*Mémoire de M. d'Espine.* p. 25,) had already suspected, that the second sound might arise from the counter-shock of the blood against the sigmoid valves, when M. Rouanet (*Theses de la Faculté*, 1832, No. 252), offered to explain the two sounds of the heart by the play of the valves; and, on this topic, presented us with most ingenious illustrations. "Numerous experiments," he says, "have proved to me, that every membrane, on passing from the state of relaxation to that of sudden tension, yields a sound, which varies according to circumstances, and is more or less intense in proportion to the powers of tension. Its tone increases with the fineness and extensibility of the membranous tissue. The greater size, thickness, and extensibility of the membrane, render the sound duller, and the substance, to which it is attached, modifies the quality of sound, in proportion to its thickness, softness, and elasticity."

M. Rouanet, applying these propositions to his theory, attributes the first sound to the sudden approximation and tension of the mitral and tricuspid valves during ventricular systole, and the second to the brisk tension of the sigmoid valves, owing to the counter-shock of the columns of blood in the aorta and pulmonary artery. "The first sound is loud, and depends to a certain extent on the energy of the ventricles, and is duller than the second. The valves, which occasion it are larger, and the walls which conduct it thicker. The second sound is sharper, because the valves are smaller, thinner, and attached to more sonorous walls."

M. Rouanet has endeavored to prove, by the following experiment, that his explanation of the second sound is correct: "I tied a portion of the aorta below the sigmoid valves, round a glass-tube of about an inch in diameter, and from

two to three inches long, opening at the lower extremity, into a bladder filled with water, and uniformly adapted to it. The portion of the arterial trunk above the valves, was then attached to the interior extremity of a second tube, of the same diameter, and more than four feet high, intended to compensate by the elevation of the fluid column, for the powers of impulse, which exist in the normal state, either in the blood or in the arteries and the contiguous parts. Then seizing the apparatus near the unobstructed valves, and holding it to the ear, so that nothing intervened but the phalanges of the fingers, I imitated as near as possible the pulsations of the heart, by suddenly compressing and relaxing the bladder with the left hand, whereby an alternate current of water was made to traverse the superior tube. The moment I relieved the bladder, in order to allow the liquid to descend, I heard a very distinct shock, which reappeared as often as I repeated the experiment. Its loudness was proportional to the height of the liquid column, and its tone very analogous to the second sound of the heart. I say analogous and not similar, for no one will surely here expect a perfect resemblance, since the conditions are so different; for there exists no resonance of the thorax, no vital resistance of the tissue, no compression of the contiguous organs. The sound thus obtained differed from that of the normal character chiefly in not being so abrupt and striking, arising from the less energetic impulse of the blood against the valves, on account of the artery being easily distended by that liquid. This laxity of the vessel, sensible both to the eye and to the touch, was still more apparent in the pulmonary artery, which, when subjected to the former experiment, gave the same results."

M. Piorry has also made experiments with the view of illustrating the question, (*Traitê de Díagn. t.* 1, *p.* 129). "The pipe of a syringe was introduced into the inferior vena-cava; the pulmonary artery was then opened, and a current of water established through the right heart, the fluid passing freely through the pulmonary artery. At the same time the region over the sternum being examined with the stethoscope, the passage of the fluid was very distinctly heard, and the sound emanating from it was very analogous, at one time, to that generally attributed to the ventricle, at another to the sound of blowing. It varied with the increased action of the piston, and with other circumstances difficult to determine."

"One of the pulmonary arteries was then laid bare, and the aorta opened, not far from its termination: A current

being then established through the left cavities of the heart, the sounds became still more manifest; their analogy to those of the heart was perfect, their character varying from blowing to dulness."

These experiments were repeated after having obliterated the sigmoid or the mitral and triglochine valves, and the same results were obtained; the sounds were, however, more distinct towards the right side than towards the left, and louder in the ventricles than in the auricles.

M. Piorry has drawn, from this, the conclusion that the principal cause of the sounds of the heart, below the sternum, is the passage of the blood through that organ, and not by any means the motions of the heart against the sternum; and that they are not owing to the play of the valves, since they continued although the latter were destroyed. He adds, (loco cit. p. 135): "If we had not to combat the whole theory of synchronism in the contractions of the right and left heart, we might be tempted to attribute the dull sound to the contractions of the left heart, and the sharp sound to those of the right heart; this would explain to us, why we hear the sharp sound to the right side, and the dull one to the left. The actual state of science renders, however, such an explanation abortive, as it is opposed to all we know and believe of the succession of the pulsations of the heart."

This theory, which the author seemed to abandon in the very act of proposing it, was still more decidedly condemned by him, (loco cit. p. 602,) after he had assured himself, by other experiments, of the truth of the old belief, which considers the pulsations of the ventricles as simultaneous, and the contraction of the ventricles and auricles as alternate. Having, therefore, modified his former notions, he expresses himself in these terms, (loco cit. p. 140): "In our opinion the causes, which produce the normal sounds of the heart, are as follows: 1st, the passage of the blood through the heart, and especially through its orifices, 2d, the friction caused by the column of blood against the walls, or taking place between the molecules of this dense liquid. The valves play a part in the production of these phenomena similar to that of the other portions of the heart. The dull sound is invariably heard during the systole of the left ventricle; but we have not yet sufficiently investigated the causes of the sharp sound, which seems to depend on the passage of the blood through the right cavities, for it is principally heard on the right side. It yet remains to be discovered, in what portions of these

cavities, and by what species of movements, this sound is produced."

Notwithstanding the objection, founded on the continuance of the sound after the obliteration of the valves, an objection, which does not appear conclusive, since the experiments of Piorry have merely proved, that sounds more analogous to the various kinds of blowing than to normal sounds are possible, although the valves are not concerned in their production, notwithstanding this objection, the theory of M. Rouanet was favorably received, and has been adopted by Dr. Billing, (*Med. Chirurg. Review, April*, 1833,) Filhos (*Theses de la Facult.* de Paris, June, 1833, No. 132, p. 10); Berard (*Dict. de Med.*, 2d edit. t. viii. p. 199.) Other authors have admitted its truth only as regards the second sound; these are MM. Guyot (*Theses de la Fac. de Paris*, June, 1834, No. 163.) and Carlile, who erroneously attributed the first sound to the entrance of the blood into the arteries during the systole, since the sound persists even after the arterial orifices are closed by compression, (*Hope, p.* 153.)

M. Bouillaud (*Traité clinique des maladies du Cœur*, 1835), after having discussed the merit of the other theories advanced on this subject, and having experimentally determined that ventricular systole coincides with the collapse of the apex of the heart, finds himself, by the method of exclusion, driven to the logical necessity of explaining the sounds by the play of the valves, and by several other modifications, which he describes in these terms. (*loco cit.* T. I. p. 135): "*First sound.* Contraction of the ventricles. 1. Brisk and instantaneous collapse of the auriculo-ventricular valves, which come into collision with their opposite surfaces. 2. Sudden elevation of the sigmoid valves of the aorta and pulmonary artery, owing to the column of blood, which is propelled into these arteries by the contraction of the ventricles, through the ventriculo-aortic, and ventriculo-pulmonary orifices. *Second sound.* Dilatation of the ventricles. 1. Collapse of the sigmoid valves, affected partly by the vacuum, which is formed in the ventricle during diastole, partly by the re-action of the aorta and pulmonary artery; collision of the opposite surfaces of these valves in the act of closing the orifice. 2. Sudden elevation of the auriculo-ventricular valves, owing either to the vacuum just adverted to, or to auricular systole, which, in concert with ventricular dilatation, allows the blood to penetrate into the ventricles, through the auriculo-ventricular orifices."

We are aware that M. Bouillaud considers as elements co-operating in the production of the two sounds, several conditions, which M. Rouanet has not taken into account, as, for example, the falling back of the sigmoid valves against the arterial walls in the case of the first sound; and the sudden elevation of the auriculo-ventricular valves in the production of the second. These notions were also shared by M. Raciborski (*Precis de diagnostic, p.* 773.)

Notwithstanding the arguments, which plead in favor of the opinion of M. Rouanet, and notwithstanding the approval of a great number of physicians, M. Magendie, in a pamphlet read before the Academy of Sciences, attributes the sounds to a double impulse of the heart against the walls of the thorax, a view, which he had already published in his work: *Précis élémentaire de physiologie* (3 *edit.* 1833, T. II. p. 396, etc.)

According to this celebrated physiologist, the first soumd depends on the shock of the apex of the heart against the walls of the thorax, at the moment of ventricular contraction, and the dulness of this sound seems to be owing to the considerable mass of the body, imparting the shock, and to the inferior degree of elasticity of the body sustaining it. The second sound may be caused by the shock of the anterior surface of the heart, at the moment of ventricular diastole, and its greater sharpness may arise from the inconsiderable mass of the body imparting the shock, and from the sternum, which sustains the impulse, being a body much more sonorous, than the muscular wall of the thorax.

What confirms the author in this opinion, is, the fact, that, (to use his own words) "a heart laid bare, when its energy is greatest, ceases to produce a sound, if the sternum be removed, or simply placed out of its reach." This experiment seems, at the first glance, of great importance, and capable of yielding conclusive evidence. It proves, however, merely, that, if we separate the heart from the walls of the thorax by mechanical means, we no *longer hear the sounds of the heart;* and we have no right to conclude, that, because these sounds *cease to be heard* (on account of the greater distance) they *cease also to be produced*. In order that the opinion of M. Magendie may become as valuable as he considers it to be, it is necessary, that the stethoscope, applied on the heart itself, should prove, that the sounds are absent. The experiments of Drs. Hope and Bouillaud have, however, convinced us, that this is not the case.

"On the 23 February, 1834," says the Professor of La Charité, "I laid bare the heart of a vigorous cock, on which I had, before the operation, distinctly heard the double sound of the heart. I examined the heart with the stethoscope, first within the pericardium, and again after this envelope had been removed. I repeated this several times, and I can affirm, that I have very distinctly heard the double sound of the *tic-tac* of the heart, though there existed no kind of contact between this organ and the walls of the chest." This *double sound* is easily distinguished from the *single sound* of friction, caused by the rubbing of the heart against the lower end of the stethoscope. M. Bouillaud adds, "I repeated the same experiment on two rabbits, and obtained the same results, inasmuch as I heard the sounds of the heart perfectly well, after the walls of the chest were beyond its reach."

The experiments of Dr. Hope on mammiferous animals, accord entirely with these facts. In one of the experiments, the heart of an ass was laid completely bare, the pulse amounting, before the operation, to 48 per minute. After having examined, by the eye and touch, what was going on, they came to the conclusion, that, in all cases where the movements of the auricles are regular, they precede those of the ventricles; at every contraction of the latter, the apex of the heart was seen to strike the thorax, and on applying the stethoscope close to the organ itself, the first sound was discovered to be synchronous with the contraction of the ventricles, and the second to coincide with the diastole.

The experiment was afterwards repeated on four young asses, and exhibited the same phenomena. On applying the stethoscope to the ventricle, the two sounds were *clearly and incontrovertibly heard* by any one accustomed to the use of the instrument. Dr. Hope, in order to satisfy himself of the above mentioned fact, directed one person to examine the heart with the stethoscope, and to count *one* for the first sound, and *two* for the second, whilst another person watched the motions of the heart, and counted in his turn, *one* for the movement of contraction, and *two* for that of dilatation. It was interesting to hear these two individuals pronounce the numbers, *one*, *two*, always at the same time, and, as it were, in unison. Hence the first sound evidently synchronizes with the systole, and the second with the diastole of the heart.

M. Bouillaud makes the following remarks: "These experiments prove, that the sounds of the heart are not produced

by the shock of this organ against the walls of the thorax; and that we are wrong in attributing the sharp sound to the systole, and the dull sound to diastole; indeed, we would henceforth commit an *unpardonable physiological absurdity*, to make the impulse and the shock of the heart coincide with the diastole of the organ."

Notwithstanding, M. Beau (*Arch. de méd.*, *Dec.* 1835, and Jan. 1839), has revived this opinion. From experimental observations made on *frogs*, he concludes: "That the motions of the cavities succeed one another in the following order:—contraction of the auricles, dilatation of the ventricles, contraction of the ventricles, dilatation of the auricles; (2nd. *mém.* p. 1.) that the summit of the heart is not propelled during systole, and that the shock of the apex against the wall of the thorax takes place at the moment of diastole, and is the effect of the dilatation of the ventricles (1*st mém.* p. 6); that the *first* or *inferior* (*ventricular*) sound is produced the moment the wave of blood propelled by the contraction of the auricles, briskly expands the ventricles: and it results from the collision of the blood with that portion of the ventricular wall, which is opposite to the auriculo-ventricular orifices. That the *second* or *superior* (*auricular*) sound is produced at the moment of auricular dilatation, by the admission of a fresh column of blood; which, being briskly discharged by the venous trunks, comes into collision with the anterior wall of the auricle." (2nd *mém.* p. 2.)

In this theory, the order of succession approaches very nearly to what is now generally considered the true one; but the coincidence between the shock and the motions is completely upset; for the shock would here coincide with ventricular diastole. But it is impossible to take this for granted, after we are acquainted with the above experiments. It may indeed be stated as an objection to this, that the opinion of M. Beau is also based on experiments. We must not, however, forget that M. Beau has made his observations on *frogs*, the heart of which differs materially from that of man; that those he has made on birds, are contradicted by the results of M. Bouillaud's investigation; finally, that those he has attempted to make on rabits and dogs, have taught him almost nothing, on account of the rapidity of the movements, and the quick termination of the contractions of the heart after the chest is laid open. He has, therefore, no right to consider the phenomena displayed in frogs, as analagous to those exhibited in the human species; the more so, as the re-

sults he pretends to have obtained, are completely at variance with those which Dr. Hope derived from a close inspection of frogs; (Raciborski, Traité de Diagnose, p. 756,) and, above all, as they are directly opposed to those furnished by the elaborate experiments of Dr. Hope and d'Espine, which were repeated several times on the larger mammiferous animals, the heart of which is very analagous, in structure, to that of man.

Is the interpretation, which M. Beau gives of the sounds, more warrantable? Can we admit, that to produce the first sound, the auricles contract so powerfully as to propel the blood against the ventricular walls, so as to cause a sound of sufficient intensity, when these auricles, especially the left, consist but of a few fleshy colums; add to this the consideraion, that on account of the absence of valves at the venous orifices of the auricles, even a small degree of energy displayed in their contraction, ought to occasion a reflux of blood into the veins, a phenomenon met with in cases of tricuspid in sufficiency; not to mention, that according to the experiments of Dr. Barry, (Laennec, III, p. 64,) the contraction of the auricles is partial, and merely at the auricular appendages.

Again, in regard to the second sound, it is true, that the blood penetrates suddenly enough into the auricles, and strikes the walls with sufficient force to occasion such a short and ringing sound, when the same experiments of Dr. Barry prove, that the auricles are reservoirs, which are constantly full, and, therefore, not in the proper condition of producing a distinct shock? But granting that these are the causes of the sounds, why should the energetic contraction of the ventricles, the brisk tenison of the valves, the shock of the blood against their collapsed walls, be performed in silence?

Any scruples remaining in the mind of the reader, in regard to the value of M. Beau's experiments and conclusions, will surely vanish before the more recent experimental results obtained by Drs. Williams and Hope, as also by the Committee of Dublin, which seem to give a very correct idea of the mechanism of the two sounds.

Experiments of Dr. Ch. Williams.—First Experiment.—Six grains of woorara were introduced under the skin of an ass, which expired in about fifteen minutes. Artificial respiration being maintained, the chest was laid open, and an incision made into the pericardium in order to expose the heart. The pulsations were regular and energetic; the auricles contracted immediately before the ventricles, and the double

sound of the heart evidently coincided with the systole and diastole of the ventricles. The following observations were then committed to paper:

1st. The first sound was heard equally loud on all points of the ventricles.

2d. The second sound was most distinct, near the insertion of the large arteries, and continued to be heard at that point, even when, owing to more feeble contractions, it became inaudible at other points of the ventricles.

3d. The second sound disappeared on pressing firmly with the finger or stethoscope on the insertion of the arteries. Slight pressure occasioned a sound of hissing or blowing, coincident with the first sound of the heart.

4th. By pushing the auricles into the auriculo-ventricular orifices, the contraction of the ventricles became more feeble and irregular; but the first sound continued to be heard, although greatly diminished in intensity.

5th. At each contraction of the heart, the finger felt the tension and elongation of the ventricles; and also something like a brief shock, coinciding exactly with the first sound.

6th. An incision was made into the left auricle, and the mitral valve partly destroyed; jets of blood accompanied each contraction of the ventricles, but the first sound still coincided with the systole, whilst the second ceased entirely,

7th. An opening being made into the right auricle, the first sound still continued.

8th. On introducing the finger through the mitral orifice into the left ventricle, and compressing the right ventricle, to prevent the blood from entering the two ventricular cavities, the ventricles continued to contract with energy; and the first sound could still be heard, though not so distinctly as if the cavities had been full of blood.

9th. The same phenomena presented themselves after the removal of the aorta and pulmonary artery.

Previously to an incision being made into the auricles, (*ut supra*, 6 *and* 7), the second sound continued as long as the pulsations were energetic; but it disappeared as soon as they were opened, although there followed at least thirty energetic pulsations. From ten to twelve powerful contractions were likewise noticed after the introduction of the finger into the ventricle. Reckoning from the commencement of artificial respiration, the experiment lasted an hour and twenty minutes.

Second Experiment.—An ass, about six weeks old, was poisoned by the introduction of fifteen grains of woorara, into

a wound made in the haunches, and expired in about thirty-five minutes. Artificial respiration was immediately established, and the chest opened by an incision through the costal cartilages, and by the fracture of three or four ribs, so as to display the left half of the cavity of the thorax. The following results were then attested by several witnesses:—

1st. Before opening the pericardium, the two sounds were distinctly heard, though the heart could not possibly be in contact with the walls of the thorax.

2d. The two sounds were still distinctly audible, notwithstanding the interposition of a lobe of the lung between the heart and stethoscope.

3d. After the pericardium had been completely opened, the second sound was most distinctly audible, at the insertion of the aorta and pulmonary artery, and was louder at that point than the first sound. It was also abrupt, sharp, und analogous to the sound of clapping. On placing the stethoscope upon the walls of the ventricles, the second sound appeared less distinct, more dull and distant.

4th. On applying the cylinder to the aorta, about three inches from its insertion, the second sound became alone audible, and succeeded the contraction of the ventricles.

5th. On keeping the aorta and pulmonary artery compressed for a few seconds, between the thumb and first finger, the first sound was accompanied by blowing, and the second discontinued, as long as these vessels were under pressure. This experiment was tried several times by Drs. Williams and Hope.

6th. A hook was introduced into the pulmonary artery, to prevent the semilunar valves from closing; in consequence, the second sound became less audible, and was accompanied by a noise of hissing. A curved awl being then inserted into the aorta, the second sound disappeared entirely, and was supplanted by a noise of hissing.

7th. On removing the hook and the awl, the second sound reappeared instantly, and the hissing discontinued. This experiment, as well as the former, was repeated, and the same results recognised by Drs. Williams, Hope, Johnson, and Malton.

8th. The sixth experiment was resumed, and whilst Dr. Hope examined with the stethoscope, Dr. Williams withdrew the awl from the aorta. Immediately Dr. Hope said, "I hear now the second sound." On withdrawing the hook from the pulmonary artery, Dr. Hope remarked, "I hear now the second sound louder, and the abnormal sound has disappeared."

9th. On making an incision into the pulmonary artery, and introducing the finger into the right ventricle, the contractions became irregular; and the first sound was still heard, but appeared duller.

10th. The contraction of the ventricles became very feeble after these cavities were opened; and the fleshy columns were seen to contract simultaneously with the fibres of the ventricular walls.

The experiment lasted one hour and ten minutes, reckoning from the commencement of artificial respiration; and, until the arteries were opened, the contractions of the heart were generally energetic and regular.

Dr. Williams drew the following inferences from these observations: The first sound is not caused, as Carlile thinks, by the admission of blood into the large arteries, (Vid. 4, 6, 7, 8, and 9, Observ. of *the first series*, and 4 and 9, of *the second*,) since the sound could not be heard at the aorta, was louder at the walls of the ventricles than at the insertion of the arteries, and persisted, even after the blood was prevented from entering the large vessels. The first sound does not depend (we are inclined to add *solely*) on the occlusion of the auriculo-ventricular valves, (Rouanet, vid. Observ. 4, 6, 7, 8, and 9, of *the first series*,) since the sound continued after the valves were more or less prevented from closing. The first sound is not produced by the molecular collision of blood in the ventricles, (old theory of Hope, vid. Observ. 4, 8, and 9, of *the first series*, and Observ. 9, of *the second*,) since the sound is manifested, even when there is no blood in the ventricles.

We may, on the other hand, consider the following points as settled:—

1st. *The first sound arises solely from muscular contraction*, (Observ. 8, and 9, of *the first series*,) as we cannot imagine any other cause to account for the continuance of the sound during the contraction of the ventricles.

2d. *The second sound is produced by the reaction of the columns of arterial blood, which produces the tension of the semilunar valves at the moment of diastole*, as is proved by the intimate connection of the seat of the sound with the position of these valves, (Observ. 2, of *first series;* Observ. 3, and 4, of *second series*,) and also by numerous observations, demonstrating, that the cessation and reappearance of the second sound corresponds with the alternate interruption and re-establishment of the play of the sigmoid valves. (Obs. 3, of *first series;* Obs. 3, 6, 7, and 8, of *second series*.)

The greater number of the preceding experiments were devised by Drs. Williams and Hope together;* the latter has, besides, made other experiments, and drawn from them the above conclusions (p. 190.) The demonstrations he gives in support of his new opinions are almost all inserted in the report of Dr. Williams' own researches (p. 202, &c.) or in that of the Committee of Dublin (*ut infra.*) We shall merely mention, that, in order to prove by analogy the possibility of valvular sounds, he imparted movements of sudden tension to strips of linen immersed in water, and recognised, by the aid of the stethoscope, sounds analogous to those heard during the pulsation of the heart.

Dr. Hope, in order to prove more particularly, that the auriculo-ventricular vavles have a share in the production of the first sound, alleges the following reasons:—"As often as the mitral or tricuspid valves were destroyed, the first sound became modified. On one occasion, I pushed a flexible steel wire through one of the points of junction between the left auricle and ventricle, and having bent it in the form of an arch, with its convex surface facing the ventricular cavity, that its curvature might prevent the tension and collision of the valves, the first sound diminished in intensity, and a distinct bellows-sound was heard, owing to the reflux of the sanguineous column. In some cases of dilatation with attenuation, or even softening of the heart, the ventricles contract feebly, and the first sound is not only less intense, but is also changed in character, for it becomes abrupt and sharp, and analogous to the clapping of the semilunar valves."

Extract of a Report from the Committee of the British Association in Dublin (11*th Aug.* 1835,) *appointed to make experiments on the Motions and Sounds of the Heart.*

These experiments were made on calves killed by a blow on the head, in which respiration was maintained artifically, the heart continuing to beat for two or three hours.

Fifth Experiment.†—On applying the stethoscope to the sternum of a calf, in front of the heart, the two sounds were distinctly heard. The first was dull and prolonged, the second abrupt and sharp. On removing the sternum along with the ribs, to prevent the heart from coming in contact with the walls of the thorax, and applying the stethoscope, armed

* See Note 2 V. † See Note 2 W.

with a flexible tube, close to the pericardium, the two sounds became again distinctly audible, (the tube was added, with the view of deadening the shock or impulse, which is generally felt in using the common stethoscope, and which is apt to disturb the attention.) On applying the ear very close to the heart, without however touching it, the two sounds were still, though feebly, perceptible. On placing a small plate of ivory upon the ventricles, and keeping it in contact with the pericardium, the two sounds were heard as distinctly, and almost as loud, as if transmitted through the sternum. The first sound became distinctly, and the second less distinctly audible, when the stethoscope was applied close to the summit of the ventricles; again both sounds, and especially the second, were clearly perceived, when the cylinder was placed on the insertion of the large arteries. On injecting tepid water into the pericardium, so as to distend it, the sounds diminished in intensity.

Sixth Experiment.—The sternum and ribs were removed as before, and the pericardium slit open. On applying the stethoscope to various portions of the ventricles, two sounds, which differed in all respects as before, were distinctly perceived, and on compressing the large arteries close to the heart, the character of the second sound underwent a change; indeed, some of the members of the Committee thought that it intermitted from time to time. The *first* sound, however, suffered no change of character.

A fine curved needle was then plunged into the aorta, and another into the pulmonary artery below the adhering edge of one of their valves. These needles were then turned so as to pierce the arterial walls about an inch farther up, and thus fix the valves. On examining the insertion of the large arteries with the stethoscope, the second sound appeared to be absent, but a sound greatly resembling the first, and coinciding with the systole, was distinctly audible. On inspecting the sigmoid valves, after the heart was removed, one of them was seen to adhere to the walls of each artery, so that its collapse was completely impracticable.

Seventh Experiment.—The preceding experiment was repeated on another calf, and gave precisely the same results; viz: the cessation of the second sound; but, in the course of the operation, it suddenly made its appearance again, although slightly modified. On examination, it was observed that the needle, which had been introduced into the aorta, had lost its hold, and after it was readjusted, the second sound

N

again disappeared. An inspection of the heart displayed the the two valves pinned up as before, and adhering to the arterial walls.

Eighth Experiment.—Immediately after the calf had been slaughtered, the heart was taken out and put on a table. On applying the stethoscope to the ventricles, whilst they were still contracting, a sound similar to the first sound of the heart, was clearly heard at each systole, but the second sound was absent. The organ having ceased to contract, the semi-lunar valves were destroyed, and the the ventricles filled with water. The heart was then held vertically, the stethoscope fixed with one hand to the ventricular cavities, and a pressure exerted on these cavities with the other hand, so as to propel a column of fluid through the arterial trunks. The accompanying sound greatly resembled the first sound of the heart.

On applying the stethoscope to the ventricles, when the heart was quite motionless, and so completely empty, that, by the pressure of the hand, the internal surfaces could be made to rub against one another, a *sound was perceived* somewhat analogous to the first sound of the heart. When the inside of the left ventricle was gently rubbed by the finger, there resulted a sound, which greatly resembled the first sound of the heart. Water, made to fall through glass tubes from a certain elevation upon the aortic valves, previous to their destruction, occasioned a sound very similar to the second; and the tube inserted into the valvular orifices, and moved gently up and down, gave rise to a sound, which had the character of grating. The Committee thought that the following conclusions might safely be drawn from these experiments:—

1st. The sounds of the heart are not produced by the shock of the ventricles against the sternum, but by motions in the interior of the heart and its vessels.

2d. The sternum and antertor wall of the thorax increase, by their contact with the ventricles, the intensity of the sounds.

3d. The first sound corresponds with the ventricular systole, and has the same duration with it.

4th. The cause of the first sound begins and ceases with the contraction of the ventricles, and continues during the whole of the systole.

5th. The first sound does not depend, exclusively, on the occlusion of the mitral and tricuspid valves, since the valvu-

lar movement only takes place at the commencement of systole, and is of much shorter duration.

6th. The first sound is by no means produced by the reciprocal friction of the internal surfaces of the ventricles, because no friction can take place until the blood be driven out of the ventricles; nevertheless, the first sound commences at the same moment with the ventricular systole.

7th. The first sound is produced either by the rapid passage of the blood over the irregular surface of the ventricles, in its course towards the arterial orifices, or by the muscular vibration of the ventricles, or, probably, by both causes combined.

8th. The second sound appears at the close of the ventricular systole, and its production depends on the healthy condition of the aortic and pulmonary valves. It seems to be the effect of the sudden resistance, which the tension of these valves offers to the retrograde motion of the columns of blood after each systole, and which is owing to the elastic reaction of the large arterial trunks.

The Committee of Dublin have drawn out this report with great reserve; they confess, that notwithstanding the labor devoted to that subject, the problem is far from being completely solved; and that new investigations are yet requisite to clear up the doubtful points.

The following table contains a condensed analysis of the different theories we have just been discussing:

	FIRST SOUND.	SECOND SOUND.
LAENNEC.	Ventricular contraction.	Auricular contraction.
TURNER.	Ventricular contraction.	Shock of the heart falling back upon the pericardium.
CORRIGAN.	Collision of the blood with the ventricular walls during diastole.	Ventricular contraction.
D'ESPINE.	Ventricular contraction.	Ventricular dilatation.
PIGEAUX. 1832.	Collision of the blood with the ventricular walls at the moment of diastole.	Collision of the blood with the walls of the aorta, and pulmonary artery at the moment of systole.
PIGEAUX. 1839.	Friction of the blood against the ventricular walls, the orifices and walls of the large vessels at the moment of systole.	Friction of the blood against the auricular walls, auriculo-ventricular orifices and cavities of the ventricles at the moment of diastole.
HOPE. 1831	Molecular collision of the blood during systole.	Molecular collision of the blood during diastole.
HOPE. 1839.	Sound of vulvular tension, sound of muscular expansion, rotatory sound.	Clapping of the sigmoid valves during diastole.

	FIRST SOUND.	SECOND SOUND.
Rouanet.	Clapping of the auriculo-ventricular valves during systole.	Clapping of the sigmoid valves during diastole.
Piorry.	Friction of the molecules of blood against one another, and against the ventricular walls, orifices, and valves, during systole of the left ventricle.	Passage of the blood through the right cavities. In which parts? At what period?
Carlile.	The projection of the blood into the arteries during systole.	Clapping of the sigmoid valves during diastole.
Bouillaud.	Quick collapse and collision of the opposite surfaces of the auriculo-ventricular valves and sudden elevation of the sigmoid valves during systole.	Collapse of the sigmoid valves, collision of their opposite surfaces and sudden elevation of the auriculo-ventricular valves at the moment of diastole.
Magendie.	Shock of the apex of the heart against the thorax at the moment of systole.	Shock of the anterior surface of the heart at the moment of diastole.
Beau	Collision of the wave of blood with the ventricular walls during ventricular diastole.	Collision of the column of blood, discharged by the veins, with the walls of the auricles.
C. Williams	Muscular contraction of the ventricles during systole.	Counter-shock of the columns of blood against the sigmoid valves during diastole.
Committee of Dublin.	Friction of the blood against the ventricular walls, and muscular contraction during systole.	Tension of the semilunar valves and counter-shock of the columns of blood during diastole.

We would have inserted, in this catalogue of theories, the opinions of various other authors, had we not found them to be void of all foundation. Amongst others we may, however, mention that of Dr. Skoda* of Vienna (*Die Percussion und Auscultation*, 1839,) who maintains that *each* of the two ventricles and large arteries is capable of producing both sounds of the heart, and also the theory of Prof. Burdach, who revives the original opinion of M. Pigeaux, that the first sound coincides with diastole, and the second with systole, and vindicates, besides, the presence of a certain quantity of air in the heart and at the origin of the large vessels, as conditions indispensable to the production of the sounds.

After all that has been said on the subject, what is our own notion of it, and what view have we embraced? We remark, in the first place, that this problem is complicated,—that there are, if we may say so, three questions comprehended in one, which we have first to consider separately. They are, 1st, the order of succession in the motions of the heart; 2d, the

* See Note 2 X.

coincidence between the motions, the shock, and the sounds; and, 3d, the cause of these sounds. The first two questions must, of necessity, be decided before we can at all attempt the solution of the third.

In regard to the first question, we think, in accordance with the experiments of MM. d'Espine, Hope, Bouillaud, Williams, and the Committee of Dublin, that *the contraction of the auricles immediately precedes that of the ventricles, which is, in its turn, succeeded by the diastole.*

In regard to the second question, we refer to the same experiments in support of the following assertion:—*Ventricular contraction coincides with the shock of the heart, and consequently with the dull sound*, (since it is proved, that the dull sound and the shock are synchronous). We are also induced to place the second sound, which follows close upon the first, shortly after ventricular contraction, at the moment of diastole. This, then, is the relation we conceive to exist between the motions of the heart, the course of the blood, and the two sounds.

Suppose that the cavities of the heart have received, from the general venous and pulmonary system, the quantity of blood requisite for arterial circulation: the play of the organ begins with the systole of the auricles. Their silent, gentle, and short contraction, which is more energetic in the appendages than in the other parts, is in some measure propagated to the ventricles. These latter, the distention of which has been *accomplished* by auricular contraction, contract briskly in their turn, and strike against the walls of the thorax.* That moment the auriculo-ventricular valves collapse, to prevent the reflux of blood into the auricles; and this fluid, compressed from all quarters, escapes through the arterial orifices, by uplifting the valves. Simultaneously with this contraction, the first sound makes its appearance, and then follows a very short pause, which is occupied by the arterial pulsations.

After the systole the ventricles instantaneously expand: forthwith the sigmoid valves of the aorta and pulmonary artery close, in consequence of the shock they sustain from the two tides of blood, which they prevent from flowing back into the ventricles; and at the same moment the second sound manifests itself, and the whole concludes with the long pause.

No sooner are the ventricular cavities empty, when the venous blood, which begins to fill the auricles the instant they

* See Note 2 Y.

have done contracting, continues to pour in from the venæ cavæ and pulmonary veins, and passes without impediment through the relaxed mitral and tricuspid valves. This process occupies about the third part of the time allowed to one pulsation, and fills up almost entirely the long pause, the termination of which corresponds with the systole of the auricles. The contraction of these latter accomplishes the filling of the ventricles, whereupon the various motions of the heart continue in the same order as before.

Let us now inquire into the *causes of the sound.* But is it not strange, that we always feel an anxiety to explain *complicated* facts, by *single* causes only? We object to such a method of exclusion, especially when several explanations of a complicated problem are equally well supported by positive results of experiment, and the no less important data of sound induction. This is exactly the case in regard to the sounds of the heart. The moment either sound is produced, a certain number of phenomena concur, to each of which we may allot a share in their productions, and to several of which, experiment proves, that a certain share is due.

Thus we may notice, as phenomena coincident with the first sound:—1st, Muscular contraction of the ventricles. 2d, Impulse of the heart against the thorax. 3d, Brisk tension of the mitral and tricuspid valves, collision of the blood with these valves, reciprocal concussion of their corresponding surfaces. 4th, Molecular collision of the blood during its compression and propulsion towards the orifices. 5th, Friction of the blood against the ventricular walls, especially at the apertures, which it traverses. Are there not, here, as many phenomena as may co-operate in the production of the sound, and may not therefore the cause of the first sound, instead of being simple, be possibly a compound of several elements, each of which contributes to its manifestation? The principal resources of the first sound seem to be ventricular contraction, proved by the experiments of Dr. Ch. Williams and of the Committee of Dublin; play of the auricular-ventrical valves, the diseases of which influence the character of the sound; shock of the heart, which, according to the experiments of the Committee, reinforces the sound.

The second sound is allied to the following principal phenomena: 1st, Ventricular dilatation and collision of the blood with the walls of the ventricles; 2nd, Brisk tension of the sigmoid valves; and, 3d, Counter-shock sustained by

their superior surface, from the tide of returning blood in the aorta and pulmonary artery. These various elements certainly contribute more or less to the formation of the sound; but the tension of the semilunar valves, as well as the collision of the blood with their concave surface, apppear to be the principal, and, perhaps, the only causes (according to the experiments of MM. Rouanet, Williams, and the Committee of Dublin,) considering, that the insufficiency of the aortic valves, involves constantly an alteration in the character of the second sound.

This view, equally based on induction, and on the results of experimental science, facilitates, moreover, the explanation of certain pathological facts, the real cause of which cannot but escape the advocates of one or other exclusive theory.

We would not insist so much on an inquiry into the mechanism of the sounds of the heart,* if practice were, in this case, not so intimately interwoven with theory; for the explanation of the pathological phenomena, derived from auscultation of the heart, will convince us, that it is of the utmost importance to arrive at a precise determination of the causes of the sounds. This theoretical knowledge will, indeed, facilitate the diagnosis of a great many diseases. The loudness of the sounds becomes thereby perfectly intelligible in hypertrophy with dilatation; their feebleness in softening of the heart; their obscurity in concentric hypertrophy; their clearness in dilatation of the ventricles, with attenuation of the walls. We have thereby gained an insight into the alterations of the character of the sound; why they appear harsh, grating, subdued, &c.; and, above all, we are enabled to appreciate the diagnostic value of the sounds of blowing, sawing, grating, &c. It is this theory, which, by informing us where to find the maximum intensity of the the physiological sounds, reveals to us the situation, and even the nature of the diseases, through the medium of the abnormal sounds. It is this theory again, which, to conclude with an example, explains to us, why a bellows-sound, perceived during the second third of the triple measure, at the base of the heart, and on a level with the third rib, necessarily arises from insufficiency of the sigmoid valves. In one word, to dispute the importance of the knowledge of the true causes of the sounds, is tantamount to questioning the usefulness of patholog-

* See note 2 Z.

ical anatomy to the medical art. There exists here, as in the diseases of the pulmonary organs, the most intimate connection between the physical *agents* of the sounds, between the diseases of these *agents*, (in other words, the anatomical alterations of certain parts of the heart,) and, finally, between the stethoscopic signs, which interpret these alterations.

§ III. Pathological Phenomena.

We have seen that, in the *physiological state*, the sounds of the heart have their maximum intensity, the first immediately below, and a little to the left of the nipple; the second about two inches higher up, a little above, and to the right of the nipple, near the left edge of the sternum; that the sounds radiate from this centre over a variable area, and decrease in proportion to their distance from the precordial region, until they vanish towards the right posterior regions of the chest; that these sounds, which are distinctly audible, are moderately intense in the state of repose; that their number varies from 60 to 80, but that their order of succession is always regular, and the relative duration of the two sounds and pauses always equal; that their tone, which slightly fluctuates, is not absolutely very dull, nor very sharp; and, finally, that they are pure, well defined, and free from accessory sounds. In the *pathological state*, the characters of the sounds are variously altered. Their *seat* and maximum intensity may be changed; the *space*, over which they are heard, may increase or diminish; their *intensity* may be greater or lesser; their *rhythm* may be disturbed; their *tone* modified; their *purity* more or less affected; and, occasionally, they may be preceded or accompanied, followed or supplanted, by *abnormal sounds*. Let us successively examine these different alterations.

I. TABLE OF THE ALTERATIONS OF THE SOUNDS OF THE HEART.

ALTERATIONS OF THE SOUNDS OF THE HEART.	I. In their seat		Local changes of the sounds of the heart.
	II. In their extent		Circumscribed sounds. Extended sounds.
	III. In their intensity		Loud sounds. Feeble sounds.
	IV. In their rhythm	1st. Frequency.	Retarded sounds. Accelerated sounds.
		2d. Order of succession.	Irregular, intermittent sounds.
		3d. Number.	A single sound. Three or four sounds.
	V. In their tone and character		Dull sounds. Sharp sounds, &c. Metallic sounds.
	VI. By abnormal sounds (Vide II Table.)		

I. Alterations in the Seat, or Local Changes of the Sounds of the Heart.

In consequence of various pathological circumstances, the point where the sounds of the heart attain their maximum intensity, may alter its position, and cease to be heard, in the space between the fourth and fifth rib, (as regards the *first*,) or towards the inferior edge of the third rib (as regards the *second*.) These local changes, coinciding with those of the shock of the organ, are the result of an altered position of the heart itself, or of variations in its figure and dimensions. In the one case, both sounds are displaced, in the other the change refers more exclusively to the one or the other, and is more remarkable in the first sound, than in the second.

The altered position of the first sound, which coincides with the impulse of the heart, is generally more correctly appreciated by the eye and the touch, which is a much easier method than that of proving the altered seat of the sonorous phenomena by the stethoscope. Sometimes, however, when the impulse becomes very feeble, the ear has to supply the deficiency of sight and touch.

The local changes, we speak of, may manifest themselves in various ways: At one time the two sounds have their maximum intensity more to the left, or more to the right side, higher up, lower down, or farther back, preserving throughout, the same relative distance, which separates them in the normal state; at another they are more than naturally distant from one another, either without deviating from the vertical line, in the direction of which they are generally heard, or with a change in their respective positions, so that the first sound shifts to the left of the nipple, and the second descends towards the right, behind the sternum. Sometimes the alteration in position affects the first sound only, and in such a manner, that the shock of the heart corresponds with the seventh or eight rib; or it is displaced latterly either to the left, or to the right towards the sternum and the epigastric region.

*Pathological signification.**—These local changes may depend upon diseases of the heart, the pericardium, the large vessels, or the contiguous organs.

The *descent* of the two sounds may be owing to tumors situated at the base of the heart, dragging the organ down-

* See Note 3 A.

wards. Their *elevation* may, on the contrary, be effected by the diaphragm being pressed upwards.

The *lateral shifting* of the sounds may arise from various kinds of tumors situated on either side of the heart, or from a considerable pleuritic effusion, with protusion of the mediastinum. We know, that it is chiefly the pleuritic effusions on the left side, which alter the habitual relations between the heart and the walls of the thorax, and that the existence of pulsations immediately behind the sternum, or even a little farther to the right, is an additional sign of pleurisy with accumulation of serum.

The *shifting* of the sounds *towards the back*, depends either on aneurism of the arch of the aorta, which in its pathological state protrudes in front of the heart, or more especially on cancerous tumors of the anterior mediastinum, (we have seen cases of these two kinds of alternations,) which push the organ towards the dorsal region, so that the pulsations become more distinctly audible, form behind on either side of the vertebral column.

The displacement, in different directions, may also be owing to various other diseases: *ex. gr.* to morbid adhesions attaching the heart, to the pericardium, with or without adhesions between the pericardium and the pleura, or to extensive rachitic deformities, which change all the usual relations between the osseous frame and the organs.

The descent of the two sounds may depend on hypertrophy, with dilatation of the auricles, in which case the apex of the heart is commonly directed outwards. The increased relative distance of the maximum intensity of the two sounds, along with their simultaneous descent or deviation, indicates an increase in the dimensions of the organ. Occasionally, aneurismatic dilatation of the right ventricle, causes the two sounds of the heart to be heard more to the left; and the shifting of the first sound to the left, whilst the second remains stationary, may arise from a partial dilatation of the apex of the heart.

II. Alterations in the Extent of the Sounds of the Heart.

The area, over which we hear the normal sounds is of variable dimensions; thus it happens, that in some patients the sounds are greatly confined to the precordial region, whereas in others they are distinctly perceived from behind, as far as

the right scapular region. Sometimes we observe them to spread, with great regularity and uniformity, in all directions, agreeably to the order of succession, which Laennec has assigned to them, (from the left anterior side of the chest to the right, and from the left posterior side to the right posterior side); occasionally this regularity in the morbid phenomena disappears, and the sounds are more distinctly transmitted in one direction than in another.

Pathological signification.—The difference in the extent of the sounds of the heart arise partly from pathological conditions of the organ itself, from alterations in volume, or, simply, from modification, in the energy of its contractions, and partly from diseases of the contiguous organs, whereby the density of their tissues, and, in consequence, their power of conducting sounds, is modified.

Accordingly, a *decrease in the extent of the sounds*, may be owing to atrophy of the heart, to concentric hypertrophy, to a state of softening or weakness, to local or general atony; or, finally, to pulmonary emphysema. In almost all these cases the shock of the heart, and the intensity of the sounds, at the precordial region, are diminished.

An *increase in the extent of the sounds* may depend on increased volume of the heart, on nervous palpitations, on a state of general morbid excitability, or on an altered state of the contiguous organs, as *ex. gr.* hepatistation of the lung, tubercles, or even pleuritic effusion. In these latter cases the increase does not observe that symmetrically decreasing regularity, which occurs in hypertrophy, or in nervous palpitations. In some consumptive persons, whose right lung is studded with tubercles, we hear the sounds of the heart much more distinctly below the right clavicle than below the left.

III. Alterations in Intensity of the Sounds of the Heart.

The intensity of the sounds of the heart may be increased or diminished; at one time they are loud, ringing, audible even to the patient, and accompanied by a powerful impulse, which imparts very sensible jerks to the stethoscope, or to the head applied to the chest; at another, they are so feeble, that the observer can neither recognise them by the ear, nor feel them by applying the hand to the precordial region. The modifications in the power and extent of the sounds are generally correlative.

Pathological signification.—The increase in intensity may depend on dilatation of the cavities of the heart, on concentric hypertrophy, on induration of the muscular tissue of the walls, on local or general nervous excitement, on plethora, or on the inflammatory reaction of some other organ upon the circulating system; in all these morbid conditions the heart contracts with increased energy. The intensity and extent of the sounds augment in proportion as the impulse is rendered more powerful, except in passive dilatations, where the contrary takes place.

The decrease in intensity is owing to the opposite conditions; for example, to atrophy of the heart, to concentric hypertrophy, to diminished compactness of the muscular tissue, to retarded circulation; to general or partial atony of the nervous system, &c. In these cases, the relation between the extent, intensity, and the shock, is still preserved, except in concentric hypertrophy, which is accompanied by vigorous impluse.

Decrease in intensity is besides, attributable to other morbid conditions, resident either in the pericardium, as, for example, an effusion, which removes the heart out of the reach of the thoracic walls, and almost deadens the sounds, seeing that an osseous wall is a much better conductor of sound; or existing external to the circulatory apparatus, as, for example, the interposition of a portion of emphysematic lung between the heart and the thorax, which might more or less prevent the sounds from reaching the ear.

The observations of several authors, who affirm that they have heard the sounds of the heart *at a distance*, are of course included in the above remarks. Corvisart says he heard the sounds on holding the ear very close to the thorax. Laennec assures us likewise, that on more than twenty individuals, he could hear the palpitations of the heart at a distance, varying from two inches to two feet, and he adverts to the fact, that the first sound only was audible at a distance, and never the second. He fancied (T. III. p. 95.) that this phenomenon might be accounted for, by ossification of the apex, or of some other part external to the heart, and various reasons induced him to believe, that more or less abundant exhalations of gas in the pericardium had a certain share in its production.*

M. Bouillaud (T. I. p. 2.) has likewise met with individuals,

* See Note 3 B.

where the sounds became so intensely loud, owing to transient or really morbid palpitations, that they could be heard at a considerable distance from the chest; there existed, however, in these patients no pneumo-pericarditis; indeed M. Bouillaud thinks that pneumatosis is more apt to diminish, than to increase the sounds of the heart.

IV. Alterations in the Rhythm of the Sounds of the Heart.

The alterations in rhythm refer either to the number of pulsations in a given time, in other words, to their *frequency* or to the *order of succession* and relative duration of the sounds and pauses; or, finally, to the *number of sounds* corresponding with each pulsation.

1. *Frequency.*

The number of the double sounds of the heart may, in the morbid state, amount to more than 80 per minute, or fall short of 60, with or without considerable modification in the relative durations of the three thirds.

Greater frequency of the pulsations is of common occurrence, and indicates certain morbid conditions of the heart, or of other organs of the system. It forms one of the principal elements in fever, and also in inflammatory complaints, and is generally proportional to the intensity, severity, and extent of the disease, or to the importance of the affected organ. It accompanies, farther, certain conditions of general debility and anemia, when the heart compensates for the deficiency of blood, by the greater number of its contractions. In these cases, however, it is unusual, that the pulse exceeds 160 per minute, except in children, when it amounts sometimes to 170 or 180. The latter number is only surpassed in the last stage of disease, and is generally the forerunner of death.

Again, in certain affections of the heart, the pulsations succeed so rapidly, that the finger, applied to the radial artery, feels only a kind of tremulous motion, which it is impossible to reduce to numbers. In general, these pulsations are, at the same time, irregular and tumultuous.

The sudden manifestation of this complication of characters in a patient, whose pulsations have hitherto been perfectly regular, announces, according to Laennec, the formation of

sanguineous concretions of blood in the heart. One of us had an opportunity of making observations on an individual, who labored under extreme dyspnœa, and had symptoms of a serious disease of the heart. The sounds succeeded so rapidly, that from 180 to 190 were counted per minute, and nothing beyond a tremulous motion was discernable at the wrist. One morning he was astonished to find the patient's health greatly improved; the sounds of the heart were normal, and reduced to 100, and the pulse was likewise full and regular. In order to account for this, may we not suppose, that a sanguineous concretion had taken place in one of the auricles or ventricles, which, being dissolved, became detached from the walls of this cavity, and was carried off by the torrent of the circulation? This view of the case, though not easily demonstrable in a direct manner, is at least very plausible, and we may understand, why the ventricles, because not able to receive the usual quantity of blood, would multiply their efforts to make up for this defect, by an increased number of contractions.

Retardation of the pulsations is much more rarely connected with affections of the heart, and most frequently, the causes which produce it, escape our notice. It is, however, a well known fact, that in certain cases of diseases within the encephalon, the rapidity of the circulation is reduced considerably, and that the pulsations may become as low as 40 per minute. Under the influence of digitalis, they are reduced to 30 and even lower. One of us has recorded a case at the hospital of La Petié of a young girl affected with angina pectoris; the powder of digitalis had been administered to her for six successive days, in doses of 10 centigrammes each. On the seventh day, a decoction of digitalis was applied as fomentation to the region of the heart; in consequence, the pulse and pulsations, which amounted to 60 the previous evening, were reduced to 25; the short pause was pretty nearly of its usual length, but the long pause was very prolonged.

M. Andral (*ed. de. Laennec*,p. 53.) quotes two remarkable facts of retarded circulation. In a patient, who was probably laboring under an affection of the spinal marrow, the heart performed, during several successive days, not more than 20 pulsations per minute. In another case, where several symptoms of an organic disease of the heart existed, the pulsations decreased as low as 16, and, strange to say, bodily

exercise, instead of accelerating the pulsations, tended to reduce them.

2. *Order of Succession.*

The alterations in rhythm considered under this title, are of various kinds. They consist in a modification of the *relative duration* of the sounds and pauses, or also of the entire pulsations.

The modifications in the relative duration of the *sounds* are commonly confined to the sound of systole. Accordingly, the first sound is sometimes prolonged beyond its normal duration, and continues longer than the first third. This phenomenon seems to depend on a prolonged contraction of the ventricles, arising from their inability to discharge the blood within the given time, and has been observed in some cases of hypertrophy with stricture of the arterial orifices. It follows from the explanations we have given of the mechanism, by which the second sound is produced, that it cannot add much to its natural length (unless it be supplanted by a sound of blowing.)

The alterations in the relative duration of the *pauses*, are commonly confined to the long pause. This is easily understood, for as the counter-shock, which occasions the second sound, follows necessarily close after ventricular contraction, the short pause can never be much prolonged.

The prolongation of the long pause seems often to arise from a more or less considerable impedimant, which the blood encounters in its passage to the ventricle, but may also imply an auriculo-ventricular stricture. It occurs, moreover, in those cases, which are characterized by retarded circulation.

The relative duration of *entire pulsations* is altered in the following manner: A series of slow pulsations is sometimes succeeded by a series of more rapid pulsations, after which the former series recommences. This irregularity in the pulsations is, besides, variously modified; and these latter observe sometime a species of symmetrical progression in the midst of apparent confusion. For example, there was noticed in a patient a series of three or four prolonged pulsations, succeeded by several rapid ones, which was reproduced at almost equal intervals; in another, (we have ourselves witnessed the fact,) a common pulsation was pretty closely succeeded by a more rapid one, so that at the first glance there appeared to be four sounds instead of two; but, on examining the pulse

at the carotid artery, with the view of ascertaining whether this anomaly was real or apparent, we perceived two pulsations closely succeeding each other, which clearly indicated two ventricular contractions. In this confusion of movements, the different pulsations are sometimes equally energetic, and sometimes the sounds differ in intensity.

Another species of irregularity, which alters the order of succession and the mutual relation of pulsations, consists in a pause, which returns at intervals, and is generally equivalent to an entire pulsation. It is called an *intermission*, and we might almost say, that a whole pulsation is awanting. These pauses or intermissions, recur more or less frequently and regularly in a given time, after the completion of the same series of pulsations; they necessarily produce an intermission in the arterial pulsations, although we cannot always conclude, with certainty, from the pulse, what passes in the central organ of circulation. Sometimes there happens, indeed, a *false intermission*, as Laennec calls it, when the contractions of the heart are so feeble, that the pulse is not discernable.

M. Bouillaud enumerates another species of false intermission, "which consists in a contraction of the ventricles, when *empty*. In other words, the heart makes as it were a *false* step: the left ventricle, where it commonly happens, not being sufficiently filled with blood during diastole, (a circumstances not unusual in cases of severe stricture of the left auriculo-ventricular orifice,) performs a real pulsation, not exactly over a vacuum, but at least over a very small quantity of blood."

Laennec has alluded to another irregularity, where the contraction of the auricles seems at one time to anticipate that of the ventricles, and to arrest it in the acme of functional activity, (T. III. p. 41.) Sometimes the contrary takes place, (Ibid. p. 99,) so that the ear being elevated by the systole of the ventricles, perceives all at once, instead of the clapping of the auricle, a fresh contraction of the ventricles, accompanied by a much louder shock, whereupon the heart recovers its former rhythm. But M. Bouillaud remarks very justly, that Laennec's theory of the sounds of the heart is still in want of a solid foundation, and that the same remark affects the interpretation of these phenomena.

3. *Number of Sounds.*

A third species of alteration in rhythm, consists in a per-

version of the number of sounds, which correspond with each complete motion of the heart. This perversion, to which M. Bouillaud has first directed the attention of pathologists, occurs under different, or more or less common forms. Sometimes we really hear but one sound, sometimes, on the contrary, we can distinguish three and even four.

The anomaly of hearing but *one sound*, may be explained by the extreme feebleness of one of the normal sounds, (and it is almost always the second,) or by one of them (and it is always the first) being more than usually prolonged, in consequence of its transformation into blowing, or into another abnormal sound, so as to obscure the second, and as it were to absorb it.* We have met with several cases of this kind, and M. Bouillaud has recorded one, which is very remarkable. It was the case of a young man, where auscultation revealed a very loud bellows-sound, which entirely supplanted the two sounds of the heart. It is plain, that the second sound is the more easily disguised, the more rapid the pulsations of the organ; for the intervening pause being then so much shorter, the second sound appears to be the direct continuation of the first. M. Bouillaud proved the truth of this in the following manner: he retarded the circulation by administering the digitalis, which had the effect of increasing the length of the pauses, whereupon he could easily recognise the double sound of the heart.

When *three* or *four sounds* correspond to a single pulsation, it is because a sound of blowing is sometimes superadded, which precedes or follows the sounds, but this pathological fact belongs more particularly to the history of abnormal sounds. In other cases, however, the ear perceives really three or four separate sounds.

In the case of *three sounds*, it is generally the second, which is doubled. Bouillaud says, that the triple sound is in its rhythm very like that of a hammer, which falling on the anvil, after it has struck the iron, recoils from it, and once more falling back, remains motionless. We may also occasionally mark it, according to this author, by the following rhythm: tic...tac-tac.—tic...tac-tac.

M. Bouillaud has met with this phenomenon in cases of stricture of one of the auriculo-ventricular orifices; and we easily understand why, in consequence of one of the ventricles (the left for example) emptying itself more slowly than

* See note 3 C.

the other, the counter-shock of the arterial column of blood against the sigmoid valves, occurs slower in the aorta than in the pulmonary artery, and accordingly occasions *two sounds.* The same would happen, on the other hand, if the right heart were affected.

Might not a triple sound manifest itself by a similar mechanism, if one of the ventricles affected with dilatation and attenuation of its walls, were longer in discharging the blood than the other, so that the play of the sigmoid valves, instead of being simultaneous, would be alternate?

More rarely the ventricular sound appears to be double,* and the triple sound which results fiom this, is, according to M. Bouillaud, very analogous to the *tattoo of the drummers.* This reduplication of the first sound might be explained by the hypothesis, that under the influence of the one or the other pathological condition, the ventricles contract alternately. The sound, which follows the first ventricular contraction, becomes then absorbed by the second sound of systole.

Again, the formation of *four sounds,* during a single pulsation, might be owing to a want of synchronism in the action of the two hearts, so that the irregular play of the different parts of the central organ of circulation, might occasion a succession of sounds in the following order: first inferior sound, first superior sound, second inferior sound, second superior sound.

These latter cases of multiple sounds, are, however, more hypothetical than real, and have been recognised but rarely, by the most rigorous and minute investigation: in the cases which M. Bouillaud speaks of, abnormal sounds are almost always superadded to normal sounds. Besides, the alterations in rhythm alluded to (p. 160,) where a loud pulsation is constantly followed by a shorter and more feeble pulsation, may be apt to deceive us by their perfect resemblance to quadruple sounds.

But whether the existence of these multiple sounds be real or apparent, let us keep in mind, that M. Bouillaud "has observed them only in individuals laboring under stricture of one of the orifices of the heart, with induration of the valves, and commonly accompanied by the secondary effects of pericarditis."

Having given a description of the alterations in rhythm, let

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* See Note 3 D.

us remark, in addition, that these different anomalies of the sounds of the heart are sometimes isolated, and in that case, their differential diagnosis presents no difficulties; sometimes, on the other hand, their greater or lesser complications renders the pulsations *confused* and *tumultuous*, when it is often impossible to say, what species of irregularity the stethoscopic phenomena indicate.

Moreover, all these various perversions in rhythm may be transient or permanent, variable or uniform in intensity, more developed in the right heart than in the left, and vice versa.

Again, their semielogical value may greatly change, according to their degree, their character, their isolated or conjoined existence, their continuation or intermission, and especially according to their concomitant local or general symptoms.

In this respect the alterations in frequency, furnish to the diagnosis very vague indications, when the pulsations do not exceed the maximum of 150, or the minimum of 40 per minute. In any other affection but disease of the heart, their number amounts in the adult to 150, and often indicates as we have remarked above, the approach of death. The sudden rise of the pulsations in disease of the heart from 180 to 200, might sometimes lead us to suspect the formation of polypiform fibrous concretions.

The perversions in rhythm will also be of little value, if they be transient, and supperadded after the evident operation of a cause capable of disturbing the pulsations, above all, if they be isolated, and not coincident with other signs of an affection of the heart. In this case, they may be observed in individuals, whose central circulatory apparatus is free from important lesion, and may indicate solely an anomalous disposition of the nervous system (*nervous palpitations.*) On the other hand, if they be permanent and independent of any external physical cause, if several exist in combination, and be accompanied by other symptoms of an organic disease of the heart, (cyanosis, œdema of the extremities, &c.) they become much more valuable to the diagnosis and prognosis, and are then the indications of several diseases, amongst which we recognize, morbid adhesions to the pericardium or pleura, hypertrophy, dilatation with attenuation, certain diseases of the valves, and most especially strictures of the orifices.

V. Alterations in Tone and Character.

We have seen, that the sounds of the heart may present various shades of character, without altering their normal conditions. The pathological state commences at certain limits, which it is often not easy to determine; and, at one time, the tone is considerably altered, owing to different diseases; at another, the sounds have lost their asual character of clearness.

Accordingly, the sounds may become much *duller* or *sharper*, than in the normal state, and these modifications may refer either to both or to one only. They often indicate hypertrophy of the heart, (*dull sounds*,) or attenuation of the walls, (*sharp sounds*).

Laennec, applying his theory to these alterations, attributes the duller or sharper tone of the first sound, to hypertrophy or attenuation of the ventricles, and explains the same varieties in tone of the second sound, by the presence of the same disease in the auricles. But this explanation is defective in regard to the first sound, and erroneous as regards the second, which depends by no means on auricular contraction. Indeed, as the play of the valves enters as an element into the manifestation of the first sound, and takes a very active share in the production of the second, it necessarily follows, that the changed density of the walls of the organ, is not the only pathological condition capable of modifying the characters of sounds.

There is no doubt that the condition of the parts, to which the valves are attached, influences, as M. Rouanet has proved, the character of clapping, which should be sharper, on account of the morbid attenuation of their walls, and duller according to their density. But, if we admit, that valvular clapping is one of the causes of normal sound, (and this is incontestibly proved,) we should also conclude, that modifications, affecting the valves themselves, or their density, their degree of elasticity, &c., may involve perversions in tone, and that the diseases of the auriculo-ventricular valves, and more particularly of the sigmoid valves, influence the character of the first sound, and still more that of the second.

Accordingly, the observer meets, in some cases, with "sounds of a dry and hard tone, like that produced by clapping together, briskly and vehemently, two sheets of parchment." This tone, which M. Bouillaud has termed: *clapping* or *parchment sound*, revealed, on inspection after death, a

state of hypertrophic condensation, and considerable rigidity of the left valves, and, in particular, of the mitral valve. M. Bouillaud remarks, "that, in some cases, we hear a rough and smothered sound, which is either slightly or entirely hoarse, and, on inspection after death, the valves appear rather fungoid and swollen, than really hypertrophic; they are also softer and more pliant than compact and elastic, as happened in the former case."

Amongst the alterations in tone, we have yet to enumerate another phenemenon, which is termed *metallic tinkling* of the heart. This word remind us of a stethoscopic sign of the same name, which we have described, when treating of hydro-pneumothorax, and as the two sensations have little in common with one another, and, pathologically considered, are quite different, this identity of terms may occasion serious confusion. We prefer, therefore, the term *metallic sound.*

Laennec has mentioned this phenomenon. "We hear sometimes," he remarks, "a slight metallic clapping at the precordial region, in the case of nervous palpltations, especially if the heart, beating with violence and velocity, but with no considerable impulse, strikes with the apex alone against the walls of the thorax. At every pulsation of the ventricles a slight clapping sound is heard through the stethoscope, as if it occurred in the interior of its tube."

The *metallic sound* is only heard during ventricular systole; neither Laennec nor M. Bouillaud having ever heard it in diastole. It does not, however, obscure the sounds of the heart, and seems to be merely superadded. Its intensity is variable. At one time it consists merely of a somewhat sharper sound heard during systole, at another its resonance is slightly argentine, finally, in some cases, its metallic tone is strongly developed. It is transmitted to the ear according to the law of propagation of the normal sounds of the heart. It is, besides, more easily heard in lean than in stout persons, and uniformly more intense in all diseases, which are capable of increasing the power and frequency of the pulsations.

The tinkling is very well imitated by applying the palm of the hand to one ear, and knocking with the finger of the other hand on its back. On account of this resemblance, M. Filhos, (p. 14, Thèses of Paris, 1833, No. 132,) has proposed the term, auriculo-metallic tinkling. M. Bouillaud explains the phenomenon by analagous mechanism. He believes it to be produced by the shock of the heart against the region of the thorax, "which yields no sound in the normal state," but

which might occasion it, either under the influence of very violent pulsations, or in cases of ossification of the heart and pericardium; where, to use the expression of Corvisart, the heart resounds like a horn.

Dr. Hope proposes, as we have seen, a similar explanation. He thinks, the metallic tinkling depends on the shock of the heart against the inferior edge of the fifth rib, protruding inwardly, as happens in very lean persons. He is confirmed in this opinion, because he is able to stop the metallic sound at will, by pushing inwards the intercostal cartilage, either with the stethoscope, or with any other substance, so as to bring it into the same plane with the rib.

Laennec has expressed himself very differently as to the cause of the clapping sound. According to him, "it seems to take place, when the heart, being voluminous or distended with blood, becomes tightly closed up by the anterior mediastinum, and by the presence of air-bubbles in the pericardium."

Other observers (*MM. Delaberge and Moneret. Compendium, &c.*, T. I. p. 501,) have fancied, that metallic tinkling arises from the agitation of liquids contained in the stomach, and mingled with gas; an agitation, which results from the energetic impulse of the heart.

M. Piorry (*Traité de Diagnos.* T. I. p. 114,) seems to incline to this opinion. He appeals to the observation of M. Dechambre, who has sometimes recognised metallic tinkling, in a large number of patients affected with hypertrophy of the heart, who discharged a great quantity of elastic fluid by the mouth. Percussion revealed the presence of liquid and air in the stomach.

We readily believe, in the opinion of Dr. Williams, and the Committee of Dublin, according to which the shock of the apex of the heart against the thorax, *influences the first sound* even in the normal state; that this impulse of the organ, which, in the ordinary conditions, produces only dull sounds, is capable of yielding more resonant sounds, if any morbid condition be superadded, as, for example, an induration of the apex of the heart, a more energetic impulse, or a superior sonority at that point of the thorax, which sustains the shock.

At all events, the metallic sound is far from being of great importance in semeiology. The pathological signification has not yet been precisely determined, except that palpita-

tions seem to be the morbid condition, with which it is principally connected.

The above mentioned alterations in tone, are at one time confined to a single sound, at another, both sounds of the heart have lost the character of their natural clearness and purity. They become, in one case, somewhat *blowing;* in another, *rather grating;* and it is these slight modifications, which constitute the transition series from normal to well developed abnormal sounds. Pathologically speaking, they indicate the first stage of different diseases, the presence of which is declared in a more advanced stage by abnormal sounds, properly so called, which we shall describe immediately.

The alterations in the tone and character of the sounds may be also more developed on the left of the precordial region, than on the right, and *vice versa.* If, for example, the sounds were strongly marked on the left, whilst they appeared normal on the right side, the walls and valves of the left heart would be more particularly affected.

VI. Abnormal Sounds of the Heart.

We comprehend, by this term, particular sounds which are foreign to the physiological state; they mingle with the two sounds of the heart, or supplant them.

These *abnormal sounds* are naturally divided into two groups; 1st. Those produced in the cavities of the heart; 2d. Those formed external to the organ in the pericardium. The former are designated by the generic term: *sounds of blowing*, (*bruits de souffle*), the latter by that of *sounds of friction* (*bruits de frottement*). Some authors amalgamate them under the term: *sounds of friction*, and reserve the word *pheripheral friction*, to those, which occur on the outside of the heart.

II. TABLE OF ABNORMAL SOUNDS OF THE HEART.

ABNORMAL SOUNDS.	I. GENUS: SOUNDS OF BLOWING. - - -	A. Sound of blowing.
		B. Sound of grating.
		—— of filing.
		—— of sawing.
		C. Musical sounds, whistling, &c.
	II. GENUS: SOUNDS OF FRICTION. - - -	Sound of rustling.
		Sound of friction.
		Sound of new leather.
		Sound of rasping.

I. Genus.—Sound of Blowing.

Various kinds of sounds are peculiar to this genus: Sometimes we hear a regular soft blowing, emphatically termed *blowing*, (*gentle blowing*); sometimes the sound appears harsher, imitating, to a certain extent, that of a *grater* or *wooden file*; sometimes, again, the sound is shriller, similar to that of *sawing*. In other circumstances, the abnormal sound is rather sonorous and *musical*, somewhat analogous to a more or less acute cry, or, also, to *whistling* or *whining*, &c., of variable intonation.

These various sounds are of different intensity and duration. They precede, accompany, follow, or supplant one or both sounds of the heart, are permanent, or interrupted by short intervals, appear more or less frequently, and their pathological signification is more or less defined.

A. *Sound of Blowing.*

Synonyms.—Bellows-sound, gentle blowing.

Characters.—Of all abnormal sounds, that of blowing is certainly of the most frequent occurrence; its very name gives an exact description of it. Being of variable intensity, it is at one time scarcely discernible, at another very energetic; in one place it is a gentle murmur, in another a harsher species of blowing; sometimes it is limited to a small surface of the precordial region, while again it is heard over a more considerable space, and occasionally as far as the inferior portion of the sternum, in the epigastric region, or towards the left superior regions of the chest, as far as the carotid arteries. It supplants much more frequently the first sound, than the second, is generally single, and either very short or so much prolonged as to obscure both sounds of the heart. Whether permanent or intermittent, it is met with as often as we explore the chest, or it shows itself only at intervals. Its appearance is occasionally sudden and with considerable intensity; but its progress may, on the other hand, be slow and gradual. At one time, again, it is isolated, and at another accompanied by a sound of blowing in the arteries at a distance from the heart.

All these differences must be known before we can precisely determine the semeiological value of the sound of blowing, for as it may be the interpreter of a great many morbid conditions, it offers of itself very vague indications, so that we

can derive no decisive conclusion from the mere fact of its existence. An attentive examination of the differences we have pointed out, will, however, often inform us of the peculiar disease, from which it has its origin.

Physical Cause.—The diseases, which are connected with the sound of blowing, are, stricture of the orifices, and insufficiency of the valves; in which cases the membranous flaps of the valves rendered unfit for the complete occlusion of the orifices, allow the reflux of a certain quantity of blood. The bellows-sound is also recognised in other alterations, presenting an obstacle to the free passage of the blood into the chambers of the heart; such as effusions into the pericardium, fibrous concretions, and hypertrophy with dilatation of the ventricles, which alter the relations between the diameter of the orifices, and the normal quantity of blood traversing them at each contraction.

The sound of blowing is in these cases attributed to excessive friction of the blood against the walls of the canals, in which it circulates, and the mechanism of it is easily conceived in strictures, when the current of fluid, compressed on all sides by the edges of the contracted orifice, rushes rapidly through the aperture, so that the intensity of blowing and of friction is in direct ratio to the smallness of the orifice, to the more rugged condition of its circumference, and to the impetuosity of the projected blood. Friction is likewise easily explained in cases of insufficiency, which is nothing else than a stricture running in a direction favorable to the motion of the blood.

We explain the production of the sound on the same principle, when a fibrous concretion has been deposited on the walls of one of the cavities of the heart, and especially on the orifices and valves, as also in the case of dilatation with hypertrophy, when a considerable quantity of blood is forcibly projected by the enlarged ventricle, through a disproportionally small aperture. Finally, in abundant hydro-pericarditis, there may appear an excessive friction of the blood against the walls of the large arterial trunk, when compressed by an effusion within the pericardium. Indeed, we have often perceived a sound of blowing in cases of hydro-pericarditis, when the patient was lying on his back, whilst this phenomenon diminished considerably, or ceased altogether in the sitting posture.

Is this theory of the sound of blowing, which holds true for a great many cases, of constant and universal applica-

tion?* In other words, is blowing always heard when stricture exists, and can we always conclude from the existence of blowing, that there is stricture or any other material cause of friction? Neither of these propositions is absolutely true; for strictures of the cardiac orifices have been found on inspection, in cases where the bellows-sound had never occurred during life; this proves that some other conditions must necessarily be associated with stricture. On the other hand, auscultation often reveals distinct sounds of blowing, although inspection shows nothing of the above mentioned physical lesions.

We may easily account for these apparent anomalies, if we reflect a little on the mechanism of circulation. Are not the following three elements requisite to establish the action of the heart, viz: the *organ* itself, the *fluid*, which traverses it, and the *power* which, regulates its action? If one of the wheels in this mechanism become damaged, a certain amount of disturbance will take place, and the sound of blowing may be the interpreter of it.

Experiment is here not at variance with reasoning. A great many practitioners have noticed a bellows-sound, when the blood was evidently altered in its constituents, as in anemia, chlorosis, etc. Some observers have likewise pointed out its presence in hypochondriacal and hysterical persons, etc. On the one hand, the impossibility of reconciling these latter facts with an appreciable material disease in the organ or fluid; on the other, the mobility of the phenomenon, its occasional very remarkable intermittence, and, above all, the predominance of a nervous temperament in those individuals, have perhaps, for want of a better explanation, induced physiologists to suppose the influence of a disturbed nervous action of the centre of the circulation. It is at least an incontestible fact, that any derangement whatever, in the unknown moving power of the heart, may, under certain circumstances, reveal itself by sounds of blowing; thus an excess of energy in the propulsion of the blood, occasions sounds of blowing in patients, who do not present any irregularity during repose.

But why do these abnormal sounds not appear, whenever the contractions of the heart become very energetic, under the influence of a moral emotion, or violent exercise? We reply, in regard to this particular fact, that if an excess of energy be not of itself sufficient to cause a sound of blowing, when the heart and the whole economy are in a sound con-

* See note 3 E.

dition, it may be produced in a person, whose heart, or general health, is morbidly affected, and may thus act as a *determining cause*, superadded to a *predisposing cause.*

Accordingly, the production of the phenomenon requires either the concurrence of several pathological conditions, (material lesion of the organ, physical alteration of the blood, or a simple disturbance in the play of the machine,) or some single but intensely developed condition. The sound is, therefore, not produced if one of these elements, capable of eliciting it, be affected with an isolated and not very well defined lesion; nor will it appear, if two or three diseases in combination, be little marked, whereas the contrary takes place, even when only one element is acting, provided always that the alteration be well characterised, and its appearance is almost certain, when, from a combination of complex and intensely developed alterations, several elements concur in the formation of the phenomenon.

Pathological Signification.—Whatever the mechanism of abnormal sounds, and especially that of blowing, may be, let us review the diseases, in which it may be produced. These may be arranged, according to the various disturbing elements, under three sections, the first of which is more developed than the others. The third, if we may use the expression, is only *provisionary.* The number of affections, which it embraces at present, will undoubtedly be reduced with the progress of science, and finally disappear, upon the solution of the mystery, which conceals the primary cause of certain phenomena.

To the first section belong the organic *diseases of the heart;* stricture of the orifices, congenital or accidental, or arising from induration and thickening of the valves; inflammation of the internal membrane of the heart; vegetations, fibrous and pseudo-membranous deposits, &c., which form an obstacle to the current of blood: swelling and thickening of the valves, whence these stiff and rigid membranous flaps shut imperfectly, and cannot prevent the retrograde motion of the columns of blood; abnormal adhesions of the valves to the ventricular or arterial walls, ruptures, perforations, destruction or congenital absence of one or several of these valves causing insufficiency; dilatation of the auriculo-ventricular orifices, consecutive to augmentation of the cavities, or of the aortic orifices, in consequence of aneurisms of the aorta, dilatation which still allows the reflux of the blood, polypiform fibrous concretions, formed in the ventricles, or

near the orifices, simple hypertrophy, with ventricular dilatation, abnormal communication of the right and left ventricles; effusions into the pericardium.

The second section embraces *diseases with alteration of the blood*, either in quantity or in quality, as happens, for example, in anemia following profuse hemorrhagies, or to other debilitating causes of long duration; in chlorosis, where the blood undergoes considerable change; in certain forms of cachexia, where the impoverished condition of the blood coincides with a gradual vitiation of all the humours of the system; in some cases of plethora, &c.

Finally, to the last section belong *diseases, with derangement of the nervous energy*, regulating the action of the heart. These are, either general affections, as hypochondria, hysteria (*Laennec*), or local diseases, specified by the name of neuroses of the heart (*nervous palpitations*), &c. We observe, also, that these sounds of blowing, provisionally explained by nervous disturbance, and so easily recognised in hypochondriacal and hysterical persons, will be connected, perhaps, at a later period, with some physical alterations of the liquids or solids.

Are these sounds of blowing, which we ourselves have heard, and which other observers have, in like manner, perceived at the precordial region during a fit of intermittent fever, in pregnancy,* after delivery, during the progress of pneumonia, or of other affections not complicated with endocarditis, and even in apparently healthy individuals, to be registered under the third section, or under the second, or under both?

We are not always able to decide, what is the real cause of the sounds of blowing, so frequently heard in acute rheumatism of the articulations. Far from pretending, that they depend on a nervous disturbance of the circulation, or from assimilating them, with some pathologists, to abnormal sounds, caused by an alteration of the blood, we merely state, that we cannot *always* connect them with endocarditis. We certainly do not deny the connection of articular rheumatism, with inflammation of the internal membrane of the heart; but are we justified, the moment we perceive in arthritis a sound of blowing at the precordial region, to pronounce the existence of endocarditis, without ascertaining whether or not it occur along with other sensible or deducible signs of inflammation of the endocardium? This

* See note 3 F.

question we leave the reader to solve, by directing his attention to the following fact, which we have observed in the wards of M. Recamier.

A woman, thirty-one years old, entered the Hotel de Dieu on the 17th February, 1839. She had never been attacked with rheumatism, and had never presented symptoms of disease of the heart. A fortnight before her admission, she had been in the habit of sleeping in a damp room, facing the north, close to a wall, in consequence of which she was seized with fever, and felt severe pain in the arms and legs. The first day we recognised a painful swelling on the right elbow, in the joints of the left arm, and of the tibio-tarsal articulations, accompanied with fever and slight delirium. The pulse was full and regular, and a sound of blowing became distiuctly audible at the region of the heart. On the 20th February the delirium increased, the rheumatism became very acute in the right shoulder. The region of the heart was dull on percussion, over a space five fingers broad and four and a-half deep; and the pulse being one hundred, was irregular, like the pulsations of the heart, which yielded a very distinct sound of blowing during the first third, (a pound of blood was taken by the lancet, for the first time, which appeared very sizy.) She died on the 2d of March; and, up to that period the blowing sound was clearly discernible,—at one time it bore a harsher and almost grating character, while at another it was more gentle. The dulness on percussion at the region of the heart, and the irregular pulse, disappeared on the 28th February; and from that day the articulations became again flexible. We carefully examined this patient during life. The intensity of blowing, and its combination with other phenomena, led us to the assumption of endocarditis; and we were greatly astonished to find, on inspection after death, no trace of disease of the pericardium or endocardium. The heart, its external envelope, its internal membrane, its valves, in short, all its parts, presented the usual healthy characters.

Unless we suppose this woman to have laboured under organic disease, which disappeared previous to the necroscopic examination, we cannot help inferring from this curious case, that in rheumatism of the articulations, we are not *always* right in concluding the existence of endocarditis from a sound of blowing in the heart, especially if the latter accompany the first sound only. It would alter the case, if the abnormal sound possessed, as we shall see in the sequel, particular

characters of harshness, or if it coincided with both sounds, especially with the second, and if there were, at the same time, other signs of inflammation of the endocardium. Let us also recollect, that in rheumatism, the sound of blowing may depend on pericarditis with effusion, which is a very common complication of arthritis; but it is then accompanied by dulness on percussion at the region of the heart, except in emphysema, where the organ is covered by the anterior edge of the left lung.

Analytical Diagnosis.—How can we determine the exact value of the sound of blowing, since it occurs in so many and so entirely different affections? How can we ascertain, when it is allied with organic disease of the heart, or when it depends, either on an alteration of the blood, or on any other cause? The elements of these questions should here be considered either separately or in combination, such as the tone of the bellows-sound, the *third*, during which it makes its appearance, its persistence, its progress, and, finally, the comparative examination of the concomitant phenomena.

The sound of blowing, connected with an organic disease of the valves, is sometimes gentle to the ear, as in the case of simple insufficiency, but is more commonly harsh, and analogous to the sound of grating, filing, &c. The case is different with sounds of blowing, which, independent of valvular disease, indicate only an alteration of the blood, or a disturbed state of the nerves. Abnormal sounds are then merely species of gentle blowing, and if, from increased intensity, they become accidentally tinged with a transient sound of grating, we should consider this as an exception, for they soon recover their true character, conveying to the ear the sensation of very gentle friction.

Although we may, to some extent, judge by the tone of blowing of its import, our diagnosis is much more promoted, by inquiring, with what *third* the abnormal sound corresponds. If blowing coincide only with the first third, it may equally well indicate the presence as the absence of a valvular disease, and, consequently, it can be of no semeiological value. If, on the other hand, the bellows-sound correspond with the first two-thirds, it announces almost to a certainty an organic alteration of the orifices, and leaves no doubt about it, if it occupy exclusively the second third; for it is a fact verified by observation, which deserves to be elevated to the rank of a law, *that the sounds of blowing af the heart without organic disease, accompany always the first third, and never the second only.*

The duration of blowing, its persistence, or intermittence, form one more element in our diagnosis. When the sounds continue for months or years, they announce rather a disease of our first section, and when they are intermittent, they are chiefly allied with affections belonging to the other classes, and especially to the last. The sounds of blowing without organic alterations, and those, which reveal these alterations, differ, moreover, in their progress; some of them habitually preserve their gentle character under whatever modifications in intensity; others, on the contrary, undergo gradual transformations, as the diseases of the orifices become more serious and deeply rooted. From being gentle, they become louder and harsher, until blowing is finally changed into the abnormal sounds of grating, filing, &c.

The examination of the concomitant phenomena is, on that account, of great importance, if we wish to establish our diagnosis on a solid basis. Indeed, in certain cases, we observe local and general symptoms, which, as a whole, are characteristic of an affection of the heart, (dulness on percussion, purring vibration, alteration in the force and rhythm of the pulsations, irregular pulse, œdema of the inferior extremities, &c.) whereas none of these phenomena are visible in chlorosis, anemia, &c.; or, if some of them be united with the blowing sound of the heart or arteries, they will, at least, be isolated or transient.

Accordingly, the gentle tone of this sound, its coincidence with but one-third of the heart, (the first), its intermittence or short duration, and the absence ef the concomitant phenomena, grouped pathognomonically are all characters of blowing, which is independent of an organic disease of the centre of the circulation; whereas, the sound of blowing, indicative of valvular disease, possesses the opposite characters, of harshness, of coincidence with both thirds, or with the second only, of permanence and coincidence with complex morbid conditions. We need not add, that the combination of these characters, sufficiently important in themselves, increases their value amazingly.

But it is not enough to know, that blowing belongs to one of the diseases of our first group, we must also endeavor to find out which, amongst this great number of affections, it interprets.

If the sound of blowing decrease considerably, or disappear in the vertical, whilst it continues in the horizontal posture, there would be an additional reason for thinking, that

it depends on an effusion into the pericardium, and it would amount to certainty, if the abnormal sound were combined with vaulted figure at the pericardial region, with diminution of the shock, extensive dulness on percussion, together with greater feebleness and distance of the sounds of the heart. The increase in intensity of the sounds and of the impulse, coinciding with more considerable dulness on percussion, would rather indicate hypertrophy with dilatation. The sudden manifestation of a bellows-sound, especially during the progress of a disease of the heart, with smallness of the arterial pulse, might lead us to suspect the formation of a polypiform concretion.

The other diseases included in our first section, constitute two species, namely, *strictures* and *insufficiencies*. Our diagnosis has here to effect the solution of three questions: If a sound of blowing, indicative of an organic disease, be perceived at the region of the heart, have we to assume stricture or insufficiency? At which orifice does the disease occur? On which side of the heart?

Granting the sound of blowing to be single, let us see what happens when it supplants the first or second sound. When it takes place during the first third, it is at the moment of systole. Now the instant the ventricles contract, the blood, compressed from all sides by the walls of the ventricles, partly makes its escape through the arterial orifices, and is partly retained on a level with the auriculo-ventricular orifices. If the former be affected with stricture, or if the latter, because incompletely shut, allow the columns of blood to regurgitate, there will then be conditions capable of producing a sound of blowing. *Blowing at the first third, therefore, indicates stricture of the arterial orifices, or insufficiency of the auriculo-ventricular valves.*

If, on the contrary, the abnormal sound supplant the second sound of the heart, it occurs at the moment of diastole. The blood pours freely from the auricles into the ventricles, through the mitral and tricuspid valves, whilst the columns of blood launched by the contraction of the ventricles into the pulmonary and aortic arteries, are arrested in their retrograde motion by the occlusion of the sigmoid valves. Suppose then the auriculo-ventricular orifices to be affected with stricture, or the arterial orifices to close incompletely, there will then occur the conditions capable of producing a sound of blowing. *Blowing at the second third, therefore, indicates auriculo-ventricular stricture, or arterial insufficiency.*

How are we then to know, at what orifices the sound of blowing is produced, and, consequently, what are the affected valves? According to the demonstrations, given for the first time, by one of us, the diagnosis depends on the determination of that point of the precordial region, where the maximum intensity of the abnormal sound occurs. If this maximum exist below the nipple, towards the apex of the heart, we have to establish a disease of the auriculo-ventricular valves, if, on the contrary, above the nipple at the base of the heart, blowing indicates a disease of the sigmoid valves.

The fact becomes more positive after having settled, whether the sound propagates to the arteries, or whether it is circumscribed at the summit of the heart; in the former case it refers more exclusively to diseases of the arterial orifices, whilst in the latter it is more confined to alterations of the auriculo-ventricular orifices.

It only remains, that we confront these data with those deduced, as we have seen before, from the consideration of the three thirds, where blowing manifests itself, so as to determine the species of orifices (arterial or auriculo-ventricular) which is affected by any of the above-mentioned diseases (stricture or insufficiency.)

Accordingly, blowing heard during the first sound of the heart, with its maximum at the apex of the organ, without propagation to the large arterial trunks, indicates auriculo-ventricular insufficiency. The same during the first sound, with its maximum at the base of the heart, along with propagation to the large arteries, indicates arterial stricture. Again, blowing at the second third, with its maximum below the nipple, without propagation to the large arterial trunk, announces auriculo-ventricular stricture, whereas the same, with its maximum above the nipple, and with propagation to the large arteries, is the sign of insufficiency of the arterial valves.

Let us also recollect that the blood enters the ventricles more slowly at the moment of diastole, than it quits them at the moment ef systole ; the abnormal sounds of the latter are, consequently, more surely produced, than those of the former. Let us confront with this physiological remark, another fact, which we have often found corroborated, that the absence of abnormal sounds coincides much more rarely with alterations of the arterial, than with those of the auriculo-ventricular orifices. By observation and induction, then, we arrive at the conclusion, that stricture of the auriculo-ven-

tricular orifices is a disease, where blowing may often be absent, so that, if a patient exhibit general symptoms of an organic affection of the heart, with impeded circulation, (palpitations, dyspnœa, œdema, of the inferior extremities, &c.) *without any appreciable morbid sound at the precordial region*, we have to assume the existence of auriculo-ventriclar stricture. These propositions are also corroborated by experiment, and in various cases, where symptoms of stricture have occurred without the bellows-sound, we have, from this negative sign, foretold auriculo-ventricular stricture, and found it verified, on inspection, after death.

The considerations we have just explained, account for the absence of the abnormal sound, notwithstanding the presence of stricture; will they assist us in solving a problem, at first sight so intricate and so much at variance with our preceding illustrations? In individuals exhibiting, when alive, manifest signs of blowing, coincident with the *first sound only*, there was discovered, on inspection, a distinct stricture of the left auriculo-ventricular orifice, whereas, from theory, the bellows-sound ought to have supplanted the *second sound*, and have been produced, during the dilatation of the ventricles, whilst the blood traverses the auriculo-ventricular orifice. In these cases, however, we have often observed, that the indurated and condensed mitral valve having assumed the shape of a funnel, and being greatly contracted at the ventricular extremities, exhibits, at the same time, a species of permanently open cylinder, which allows the blood to regurgitate into the auricles at the moment of systole. It is, therefore, natural to attribute this systolic sound to auriculo-ventricular insufficiency.

We have now to show, why the sound of blowing is absent at the second third, and what we have remarked in regard to the slowness, with which the blood flows *silently* and in small quantity, into the ventricles during diastole, accounts perfectly for its absence.

We observe, besides, that, even when there is no cylindrical disposition, which permits the reflux of the blood, we often perceive, besides auriculo-ventricular stricture, asperities on the surface of the valves, which may explain the coincidence of blowing with the first third, since, under the influence of the energetic contraction of the ventricles, the blood cannot but pass turbulently over these rugged surfaces.

Suppose, at present, that we have determined, in what orifices the disease has originated, and what is its character, it

still remains to be decided, whether it belongs to the right heart or to the left. The attentive examination of the seat of the abnormal sound on the right or left, the examination of the large veins, and of the pulse, should form the basis of our diagnosis, the uncertainty and difficulty of which is really much greater, than some pathologists seem to think.

The following rule has been laid down by M. Littré, to distinguish the affected side, (Dict. de Med. 2d Ed. T. VIII. p. 335.) "When there is a stricture or insufficiency at the left heart, its morbid sound, which *at the precordial region*, marks the natural sound corresponding to the right heart, disappears the farther we remove; and, at a point on the right side of the chest, which we must try to find out, we hear only the natural tic-tac, however distant. M. Rayer has, however, observed, that the place, where the healthy right heart is best heard, when the left is diseased, is the epigastric region.

At this point I have several times very distinctly perceived the regular tic-tac, when the left heart yielded a morbid sound. Tbe contrary takes place, when the right heart is morbidly affected, we have then to search for the natural tic-tac on the left, and at some distance from the heart. Finally, when we discover a morbid sound far from the heart, and from the two sides of the chest, we conclude, that both are affected, and this morbid sound may then belong to two different kinds of apparatus, for example, to the tricuspid valve, and to the valves of the aorta; the third, during which we hear the morbid sound on either side, (as well as the point of its maximum intensity), may then serve to determine the seat and character of the disease."

We remark, that the precept of M. Littré has often been misinterpreted, and that we might go wrong in drawing a general conclusion from the *absolute seat* of the sound, as to which side of the heart was affected. At all events, it is not uniformly applicable to the diagnosis of the alterations of the auriculo-ventricular and arterial orifices.

In fact, various physical diseases situated on the exterior of the heart, such as hepatisation of the anterior edge of the lung, &c., may increase an abnormal sound on one side, and diminish it on the other, so that the sound may, for example, be more distinctly heard to the right, though it be produced at the left heart, and *vice versa*. The displacement of the heart, by changing the relative position of its various cavities, may likewise lead into error the physician, who decides only by the place, where blowing attains its maximum intensity. It

is therefore not this *absolute seat* of the sound, which should guide us in our diagnosis, but its *relative seat* at one half of the heart, in comparison with the normal sounds of the other half. We know, indeed, that both sides possess conditions capable of producing the sounds of blowing, so that one of them may be altered in the left heart, and remain normal in the right, and *vice versa.*

The maxim of M. Littré seems, as we have already said, applicable only to the alterations of the auriculo-ventricular orifices. In regard to those of the arterial apertures, we observe, if we keep in mind the anatomical relation of the aorta and pulmonary artery, that, contrary to the above rule, we should suspect a disease of the pulmonary valves, especially when the abnormal sound is propagated along the costal cartilages; whereas blowing would rather indicate an alteration of the aortic valves, supposing it to be chiefly propagated towards the sternum, whilst a normal sound were audible on the left.

The examination of the pulse assists us in discerning the diseased side of the heart. Indeed, it is evident, that the characters of the arterial pulsations will be more surely and thoroughly modified by dieases of the left heart, than by those of the right.

The pulse is in general small, in strictures of the two left orifices, and in mitral insufficiency; while, on the contrary, it is full and undulating in cases of aortic insufficiency, without stricture.

On the other hand, the examination of the large veins, and especially of the jugular veins, furnishes, in alterations of the right orifices, phenomena, which are not discernible, if the disease happen on the left side. In the case of stricture, and especially of insufficiency of the tricuspid valve, the blood regurgitates into the jugular veins. This reflux coincides with the ventricular systole, in the case of insufficiency; whereas it occurs at the moment of diastole, if it depend on stricture. But these veinous tides refer exclusively to alterations of the auriculo-ventricular orifice; and it is especially by the negative phenomena, by the absence of several of the aforesaid circumstances, that we succeed in localizing the disease of the pulmonary orifice.

If, notwithstanding all these considerations, the physician be at a loss to discover, on what side the heart is affected, he should consult the data of experience regarding the relative frequency of diseases on one or the other side of the organ.

Now, the diseases of the right valves and orifices (we do not mean to say hypertrophy) are infinitely more rare, than those at the left heart, so that if we had assured ourselves of the existence of stricture or insufficiency, and if it were impossible to discover the affected side by symptoms, the chances are greater, (at least nine out of ten,) that the alteration is to be found on the left side.

We have hitherto supposed, that blowing supplants only one sound of the heart. Let us now suppose, that it supplants both. *A double sound of blowing* may thus be related to the following four conditions: 1st. Arterial stricture and insufficiency; 2d. Auriculo-ventricular stricture and insufficiency; 3d. Stricture of both orifices, the arterial and auriculo-ventricular; 4th. Insufficiency of both orifices.

The considerations attached to the seat of blowing, to its propagation, &c., points, to which we have already alluded, serve also to determine the species of complication, which exists.

We add, moreover, that the four just mentioned complications are not equally common, and that the diseaseas of the valves involving stricture, (as also thickening or induration of those membranous flaps), may often give rise to their insufficiency. We must infer from this, that a double sound of blowing, is rather the sign of a double lesion of a single orifice, than that of two diseases, the one situated at the arterial, the other at the auriculo-ventricular orifice. And as auriculo-ventricular stricture exists often without yielding a morbid sound, it follows that the double sound, independent of the other elements of our diagnosis, indicates rather arterial stricture and insufficiency, than any of the other three complications; and since the diseases of the valves are much more common on the left, than on the right right side, a double bellows-sound generally indicates stricture of the aortic orifice, with insufficiency of the sigmoid valves.*

B. *Sounds of Grating, Filing, and Sawing.*

The names given to these various abnormal sounds, convey to us a tolerably correct idea of their character. Indeed, the blowing sound, on account of its harshness and roughness, is sometimes very analogous to the sound of a rasp or a wooden file, occasionally its tone is shriller, and like the sound of a saw.

* See note 3 G.

These harsh sounds of blowing more frequently accompany or supplant the first sound of the heart, than the second. At one time, if they combine but for a short period, they obscure only the first sound, at another, if more prolonged, they obscure also the short pause. In some cases they are so much prolonged, (vide p. 162), as completely to disguise even both sounds. Accordingly, they are in one case single, because they supplant either the first sound or the second, at another they obscure both sounds, while in another, again, they are double and supplant at once the first and the second sound.

Their intensity is besides variable. It is *cæteris paribus*, in direct proportion to the energy of the circulation, and to the force and rapidity, with which the blood traverses the orifices. The sounds are scarcely distinct, if from slowness of the circulating fluid, the friction against the apertures be very gentle; they are, on the other hand, greatly developed, if, from the opposite conditions, friction become excessive. They differ from gentle blowing, which may be intermittent, and is generally of short duration, in this respect, that they are permanent, and that in general, if the abnormal sound be once established, it will become stationary, (*hæret lateri*). Moreover, this diminution in intensity, which is owing to reduced activity of the circulation, is but momentary. When harsh blowing succeeds gentle blowing, its transformations are progressive, for on watching the disease sufficiently long, it is observed to pass successively from the sound of grating or of filing, to sounds of a shriller tone, such as sawing, and afterwards even to the sound of hissing. These sounds of grating, filing, etc., are generally accompanied by vibratory tremors, perceived by the hand, when applied to the precordial region, which are much more uncommon with the sounds of gentle blowing.

Pathological signification.—Gentle blowing exists frequently without any organic disease of the heart, but organic alterations occur much more frequently, if not constantly, with the harsh sounds just described. These abnormal sounds are connected, besides, much more commonly with strictures than with insufficiency, for this simple reason: In strictures, the column of blood moving in the natural direction of the circulation, is powerfully propelled, and rubs forcibly against the orifices. In insufficiency, the retrograde motion of the blood is less energetic, and the diminished friction produces only gentle blowing.

The sounds of grating or filing do more than merely indicate the existence of a disease of the valves or orifices; they almost always disclose its character. Those kinds of gentle blowing, which concur with organic alterations, intimate that the amount of stricture of the orifices is moderate, that the morbid productions deposited on the valves are soft, (fibrous masses, vegetations, &c.); that the surfaces of these valves are smooth, and have not entirely lost their pliancy (swelling, fibrous condensation, &c.)

On the contrary, the sounds of grating or filing indicate a harsh friction against the more contracted orifices, or against harder and rougher surfaces, (cartilaginous or osseous indurations, calcareous deposits, &c.) Shrill sounds intimate, likewise, that the valves, indurated, or variously altered, present asperities capable of *dividing*, if we may say so, the column of blood, as in the case of ossifications, or osseo-calcareous vegetations, with destruction of the internal membranous lining.

C. *Musical Sounds: Hissing, Whining, &c.*

There are, besides, other abnormal sounds, which Laennec has recognised in the arteries, and which are also produced in the heart. These are, strictly speaking, not a mere noise, but actual *musical sounds*.

At one time the hissing sound resembles "the cry or cooing of certain birds, or rather the sibilant râle heard in some cases of bronchitis" (*Bouillaud*, *loco. cit.* t. I. p. 167). At another, the sounds are deeper in tone, and somewhat analogous to distant cries, barkings, or whinings. Like the sound of grating and sawing, musical sounds coincide generally with the first third of the heart, and are sometimes so little developed, that it requires great attention to perceive them. In some cases they are, however, very loud and distinct. Although permanent in the immense majority of cases, they are occasionally intermittent, and increased or reproduced, when an accidental cause adds a fresh stimulus to the circulation.

Their *pathological signification* is almost identical with that of the sounds of grating or sawing, and they are, according to M. Bouillaud, only a higher degree of the sound of blowing, and shriller in tone, for their extremes presuppose nearly the same conditions. This musical sound, which may be regarded as an exaggaration of the sound of sawing, indicates,

indeed, valvular disease; and is connected principally with considerable contraction of the aortic orifice, caused by osseous degeneration of the valves and by calcareous deposits. One of us read before the Anatomical Society, the case of an old woman affected with organic disease of the heart, where a musical sound, very analogous to the cackling of a duck, was audible during life. The post mortem inspection revealed a stricture of the aortic orifice, with ossification of the valves and osseo-calcareous deposits, penetrating into the hypertrophied muscular tissue, and forming a species of semicircular ring at the point of junction of the left ventricle with the sigmoid valves.

2d *Genus. Sounds of Friction.*

Synonyms: Pericardial friction:—peripheral friction.— Like the two folds of the pleura in the motions of the lung, the serous surfaces of the pericardium in the normal state, glide silently over one another during the motions of the heart; but a sound, analogous to that produced by the reciprocal friction of two membranes with uneven surfaces, may originate in some morbid conditions.

Laennec conceived the existence of pericardial friction, and has described a variety of it. He even foresaw the cause of the phenomenon, which he connected with inflammation of the pericardium, and it is difficult to understand the reasons, which made him renounce that idea.*

M. Collin, (*des diverses méthodes d'explorat. de la poitrine*, Paris, 1824,) reviving this discovery, which had been undervalued by its author, was the first who pointed out, in an exact manner, the *creaking sound of new leather*, and showed its importance to the diagnosis of pericarditis. This sound is, however, but one of the varieties of friction, to which the pericardium is subject; they have since been more carefully examined, and M. Bouillaud has described them very minutely.

Characters.—By the generic name of sounds of pericardial friction, we designate several sounds of variable intensity and character, which convey to the ear a sensation, very analogous to the ascending and descending friction of two membranes with rugged surfaces, rubbing against one another. Pericardial friction is often double, when it accompanies both motions of the heart, but it is always more developed in

* See note 3 H.

systole than in diastole. Sometimes it coincides exclusively with ventricular contraction; occasionally it does not constantly accompany the first third of the heart, nor the second, and at times it seems to be intermediate. Finally, it is audible at intervals in the same patient and in the course of the same investigation, either in company with both sounds, or with the first or second exclusively.

Its intensity is generally proportional to the force and extent of the motions of the heart, but it presents various shades of character, and is of different degrees of harshness. Hence authors have established several varieties, which have received distinct denominations, such as sound of *rustling*, of *crackling* (Bouillaud), of *new leather* (Collin), and of *rasping* (*raclement*) Bouillaud).

Gentle friction or *rustling* is very analogous "to the sound produced by rubbing a piece of silk, for example, taffetas, or what is still better, fresh bank notes." It resembles also the pleuritic friction sound, peculiar to pleurisy with recently formed soft pseudo-membranes, with this difference, however, that friction of the pleura is more slowly produced, on account of the comparatively slower motions of the lungs.

Harsh friction, or the sound of *cracling*, which conveys to the ear a sensation of rapidity, is very analogous to the sound of grating. The sound of *new leather*, which is a variety of pericardial friction, and is more uncommon than is generally believed, is sufficiently characterised by its very name; it greatly resembles the sound produced by walking with shoes newly soled. Finally, the sound of *rasping* is a friction sound much harsher than the former, and "seems to be caused by the rasping of a very hard and almost cartilaginous or osseous substance against the surface of the pericardium."

Pericardial friction bears generally an evident character of proximity; it seems to occur immediately under the ear. It is audible only over a limited space, or it may, on the other hand, occupy the whole extent of the precordial region, and is then commonly more developed near the nipple. Being sometimes circumscribed, when it makes its appearance, it is afterwards propagated to all points of the thorax opposite the heart, (Hache, mém. sur la péricardite, Arch. gén. de méd. 1835, p. 14.) If well developed, it is generally permanent, that is to say, it accompanies every motion of the heart. At intervals it also loses in distinctness, and may even be absent altogether during some contractions of the ventricles. It varies, likewise, according to the posture of the patient, and, to

judge from our own observations, it is sometimes more evident in expiration than in inspiration.

If intensely harsh, it may be accompanied by *vibratory tremors*, discernible by applying the hand to the precordial region, and is perceived over the same points, and over the same extent of surface. This phenomenon, described, for the first time by Dr. Stokes, (Arch. de Med. T. IV. 1834,) and already taken notice of in an essay read by one of us in the year 1833, before the *Société Médicale d'Observation*, bears the same relation to pericardial friction, as vibratory tremors (described p. 57, under the title of abnormal sounds of respiration,) bear to plueritic friction. According to M. Hache, (*loco cit.*) it occurs more rarely than the latter phenomenon, in the proportion of 1 to 12. But, from the average of our own observations, we have deduced a very different proportion, (4 to 10.)

The time intervening between the appearance and cessation of friction, in other words, its duration, is very variable. In one case, it is only from two to three days, in another, from one to two weeks, and extends very seldom beyond a month; in another, again, it disappears for some days, returns and ceases afterwards entirely. At one time we have recognised it for two successive weeks, we then saw it return after four days absence, and continue for nearly three weeks longer. We observe, moreover, that during its duration the sound does not preserve the same degree of intensity, nor the same characters. From being at first a sound of gentle rustling it is converted into crackling, and ends sometimes with regular rasping. In most cases, after having been rather harsh, it diminishes, from day to day, and gradually disappears.

Differential Diagnosis.—In some cases the friction-sound of the pericardium is very analogous to that of the pleura, but it is easily distinguished, by its occupying, exclusively and invariably, the precordial region; and, above all, by its being synchronous with the motions of the heart, whereas pleuritic friction is synchronous with the motions of the respiratory organs.

The circulation being generally accelerated when pericardial friction takes place, the ear perceives the sensation of a rapid sound, which circumstance adds to the difficulty of distinguishing the sounds proceeding from the interior of the heart. It is thus that gentle friction is sometimes very analogous to blowing, and harsh friction to grating; but the fol-

lowing are the characters, by means of which we may establish our diagnosis: Blowing occurs frequently at the insertion of the large vessels; friction, when limited, is generally observed lower down towards the apex of the heart. Blowing seems more deeply situated and stationary, friction is more superficial and peripheral; it may change its place, and is one day more distinct on the right, and another more developed on the left side. The one is commonly simple, and coincides always with one and the same third, the other is commonly double, and, in the case of being simple, it is not so strictly synchronous with the two sounds, to which it refers. Blowing is often propagated to the carotid arteries, but the sound of friction never. Finally, permanent blowing is subject to slight variations in intensity, and changes its character only after long intervals, whereas the transformations of the sound of friction are generally much more rapid. Add to this, that the sound of blowing and of friction may occur together, and that this coincidence manifests itself by the existence of characters peculiar to each of these abnormal sounds.

Physical Cause.—The physical conditions necessary for producing a sound of friction of the pericardium, as well as of the pleura, are the presence of rough surfaces, their actual contact, and the possibility of their gliding motion. The sound is then owing to the rubbing of these asperities over one another.

Those conditions are fulfilled, when pseudo-membranes are deposited on one or both folds of the pericardium, or when ossifications, formed below the serous membrane, (of which we have seen an example), present rugged elevations. It is, moreover, requisite, that the fluid contained in the pericardium, be not so abundant as to separate the two folds, and prevent their contact, and that the adhesions be not so crowded as to impede the freedom of their movements. Under these conditions the contiguous surfaces glide over one anether at the moment of systole and diastole, whence results a friction sound, the intensity, characters, and extent of which, are proportional to the consistence and area of the pseudo-membranes, and to the energy of the motions of the heart.

Pericardial friction is commonly more intense than pleuritic friction, but the contrary might sometimes be expected, because the pleura, which lines the walls of the thorax, offers more resistance than the parietal pericardium, and is consequently in a more suitable condition for producing friction;

but, on the other hand, the visceral fold of the pericardium, closely adapted to the organ of circulation, offers greater resistance than the pulmonary fold of the pleura; add to this, that changes in the position of the heart are performed with more energy and rapidity than those of the lung. Let us also recollect, that the organ, in the act of striking the thorax, finds necessarily a point of support at the ribs, and that, in several cases, where the sound of friction is very intense, as in pericarditis complicated with hypertrophy of the heart, the pericardium applies itself close to the walls of the thorax.

Pathological Signification.—What we have said regarding the physical conditions necessary for the production of friction, indicates sufficiently that *this abnormal sound is connected with pericarditis*, but that it manifests itself only in certain phases of the disease, and all the material modifications, which may be superadded in the progress of inflammation of the pericardium, account readily for the variable intensity and characters of the sound, as well as for its coincidence with the first third, or with the second, for its extent, persistance, departure or return.

Indeed the sound of friction may make its appearance in the commencement of pericarditis, when the inflammation has induced a pseudo-membranous exudation, and when the quantity of liquid is still inconsiderable. It decreases, when the enlarged hydro-pericardium renders the friction of the two surfaces less perfect; and ceases entirely, when the effusion becomes so abundant, as to prevent their contact by the distention of the membranous sac; it reappears, however, at the resolution of the disease, when the liquid is reabsorbed; and declines rapidly when adhesions are quickly formed between the two folds, or it continues when the contrary takes place; again, it becomes harsher in tone the more compact and resisting the pseudo-membranes.

The sound of friction may be absent, if the false membranes exist only at the posterior surface of the organ, and on the corresponding parietal fold. It is confined to a small space, if the albumenous exudation takes place from a circumscribed point of the anterior surface, or if the gliding motion be limited by adhesions or by too great accumulation of liquid. It is, on the contrary, spread over the whole precordial region, if the false membranes be general, and in this case, its maximum intensity is commonly close to the nipple, where the heart rubs most vehemently against the pericardium, and where the wall of the thorax forms a point of support.

The same explanation is applicable to the frequent and sometimes exclusive coincidence of the phenomenon with systole, (when friction is most intense at the anterior surface of the heart,) to the greater loudness of the sound during ventricular contraction, to its increased intensity, arising from augmented energy of the motions of the heart, which manifests itself when the patient leans forward, so as to bring the heart into more immediate contact with the walls of the thorax, as also during respiration, which assists in rendering this contact more complete. We now comprehend why the harshness of the sound bears, *cætris paribus*, a direct proportion to the greater density and hardness of the pseudo-membranes.

Semeiological value.—The sound of the pericardial friction is as sure a sign of pericarditis as pleuritic friction is of pleurisy. Its diagnostic value is comparatively even greater, on account of the inferior number and uncertainty of the signs, indicative of inflammation of the pericardium, whereas inflammation of the pleura reveals itself by numerous and easily appreciated phenomena.

In short, *the sound of friction indicates the presence of pericarditis, with false membranes and with coincidence of a small quantity of liquid.*

The sound of rustling iadicates, according to M. Bouillaud, that "the opposite dry and somewhat viscid folds of the pericardium, (as happens at the commencement of pericarditis) are not yet covered with pseudo-membranes," or that the pseudo-membranous exudation is recent, soft, thin, and scarcely presenting asperities. Harsh friction intimates, that these pseudo-membranes or more concrete, reticulated, uneven and rough. The sound of the creak of new leather implies, in general, that they are more compact, resisting, elastic, and may have already been transformed into adhesions, which, during the motions of the heart, become subject to incessant, and more or less sudden and violent tugging, (Bouillaud.) Finally, the sound of rasping is connected with the formation of harder morbid productions, such as cartilaginous or osseous deposits in the pseudo-membranes, or those of an osseo-calcareous nature developed in the parietal pericardium, or also calcareous concretiens lodged between the fibres of the heart, and protruding from under the serous membrane which lines them (Bouillaud).

Art. II.—Auscultation of the Arteries.

Although we find in ancient authors, traces of auscultation as applied to diseases of the chest, there is not a single instance of auscultation of the arteries. For the first rudiments of this branch of stethoscopic science, we are indebted to Laennec; who has only, however, noticed a few of the most prominent phenomena. This field has of late been more assiduously cultivated by MM. Bouillaud and Andral; and still more recently M. Vernois, has treated this subject in a special work under a great many different points of view. (*Etudes physiol. et clin. des bruits des artéres; Théses de Paris* 1837, No. 478.) We shall frequently have occasion to make extracts, from the researches, with which we are thus presented, and which are remarkable for precision, and shall avail ourselves of their results.

§ 1. *Regulations.*

Immediate auscultation is seldom applicable to the exploration of the arteries. We employ the ear only in the case the arch of the aorta, which is examined at the anterior and superior portion of the thorax, and in that of the descending thoracic aorta, which is examined at the mesial line of the back. *Mediate* auscultation is, however, preferable for the abdominal aorta, and serves exclusively to explore the arteries of the neck and of the limbs [carotid, axillary, humeral, crural, popliteal arteries, &c.] In regard to *mediate* auscultation, it is of little consequence, whether the stethoscope be used with its plug or not. M. Vernois, with the view of obviating the pressure caused by applying the ordinary cylinder to an artery, has proposed "to excavate the two diametrically opposite points of the circumference, for the reception of the vessel to be subjected to examination."

Some postures of the patient are more convenient for the auscultation of the arteries than others. In examining the thoracic aorta, the patient should in general be seated, and have his back slightly bent. The recumbent posture is more suitable for the arch and ascending aorta, and is indispensable for the examination of the abdominal aorta, especially as this position favours the flexion of the knees, and the relaxation of the anterior abdominal walls. For the auscultation of the carotid arteries, the patient should likewise be lying on his back, because the neck is thus easily supported by a solid

plane; and for the examination of both sides, we may at each turn give a perfectly symmetrical inclination to the head, which should, moreover, be raised by a pillow, and slightly bent to the side opposite to that which we examine. If it were forcibly twisted back or aside, the stiffness and tension of the parts would alter the character of the arterial sounds.

The recumbent posture is likewise more suitable for examining the arteries of the limbs, and if we explore the brachial or radial arteries, the arm should be held at a short distance from the body; when the crural arteries are the subject of examination, the lower extremity should be half bent, the thigh slightly abducted, and the outside of the knee supported by a pillow, so that the limb may remain immovable without any muscular exertion. The examination of the popliteal arteries requires the patient to lie on the stomach, and the leg to be gently supported by a pillow, in order to avoid too strong a tension of the ham, which might alter the sounds.

The parts to be examined, should generally be uncovered, as in the case of the carotid, brachial, popliteal arteries, &c. and only covered with a thin garment, when we have to explore the aorta or crural artery of a female.

In examining the different portions of the aorta, the physician may place himself indifferently on the left or right side of the individual; in regard to the arteries of the neck and limbs, the side corresponding with the vessel is preferable. He should take care not to press too much with the stethoscope, lest he occasion a partial contraction of the artery, and consequently artificial sounds.

He should, moreover, examine on both sides, and compare the results obtained from this double examination, for it may assist him to decide, whether the sound depends on local disease, or whether it is connected with an alteration of the blood, or with an organic lesion of the heart. It is of course understood, that he establishes on each side the exactly identical conditions, both as regards the posture of the neck and limb, and as regards the application of the stethoscope, its perpendicular direction towards the artery, and the degree of pressure exerted upon it. One precaution is particularly necessary for the exploration of the carotid arteries, which consists in avoiding contact of the stethoscope with the laryngo-tracheal tube.

"The external carotid arteries," says M. Vernois, "require the wider extremity of the stethoscope, to be applied on a

level with the larynx, in such a manner, that a tangent passing through its superior edge, traverses at the same time the highest point of the thyroid cartilage; its internal side should be some lines distant from the larynx. The examination of the common carotid and subclavian arteries, is performed by placing the instrument above the central portion of the clavicle, at the natural division of the two inferior and anterior fibres of the sterno-mastoid muscle, and a little on the outside of it."

When we examine the thoracic aorta, we should ask the patient to breathe as gently as possible, in order that the diminished respiratory murmur may less obscure the sounds of the artery.

§II. Physiological Phenomena.

On exploring, in the normal condition, an artery of a certain volume, for example, the crural artery in an adult enjoying good health, and in a state of rest, the ear perceives at each arterial dilatation, a slight and somewhat sonorous murmur of mean intensity, and almost of a dull character, a murmur *sui generis*, of which auscultation gives a more correct idea, than can be expressed in words. This sound, synchronous in each artery with the pulsation of the vessel, occurs generally single,* and is repeated from 60 to 80 times per minute at equal intervals. It is short, and generally not very intense, but always accompanied by a slight elevation of the artery.

Different conditions may modify its character and loudness;—these are the caliber of the vessel, the proximity of the heart, the thinness of the anterior walls, the quantity and quality of the blood which traverses them, as also the rapidity of its course;—the sex of the individual, his age and constitution;—the degree of momentary tension imparted to the artery or to its surrounding parts, by the posture of the individual, and by the pressure of the stethoscope.

The arteria sound commonly increases in intensity with the volume of the vessel; and, occasionally, it is not of the same uniformity in two arteries of equal caliber. "The right carotid artery," says M. Vernois, "has always, according to my experience, given a louder but not so full and sonorous a sound as that on the opposite side. The crural arteries, on

* See Note 3 I.

the other hand, produce a gentler and softer sound than the carotid arteries. That of the brachial and radial arteries is proportional to their volume, and its intensity diminishes with their caliber; nevertheless, the sound is, in this case, remarkable for its hardness, brevity, and dryness."

The sound is duller, when the artery is very full and enclosed by thick walls; but the contrary takes place when "the arteries are somewhat soft and flabby, when they contain less blood than in the normal state, or when this fluid is too liquid and aqueous; for the sound is not so dull, imitates the sound of waves, and shows a tendency to pass over into the sound of blowing, (Bouillaud)." Apart from other causes, it increases in loudness as the circulation becomes more energetic and rapid.

"In women and little girls," says M. Vernois, "the arterial sounds are more conspicuous, but less harsh and dull. In old persons they are remarkable for their harshness, dulness, and sometimes for their dry and rapid sonority. In children, who often exhibit blowing without any disease, they are more gentle and sonorous." The sounds are more distinct in lean than in fat persons, because the arteries of these latter are surrounded by adipose tissue, which obscures the sound.

Arterial murmur is likewise louder and harsher when the parts are greatly stretched, for example, when the thigh is straightened out, or when the neck is forcibly twisted back and to the side opposite to that, which we examine. Finally, the degree of pressure exercised by the stethoscope is one of those external conditions, which greatly influence the character and intensity of the sound; a slight pressure exaggerates it, a stronger one converts it into blowing. "The compression of an artery, at a point not very distant from that examined, increases, almost constantly, the intensity of the sounds, and is sometimes sufficient to produce sounds of blowing." (Vernois.)

Theory of the arterial sounds.—With the view of discovering the physical causes, and the mechanism of the production of the arterial sounds, it became an object to produce artificially the phenomena of circulation; and when, by means of a piston, liquids were forced through tubes, the examination of their external surface revealed a sound, the loudness and character of which varied with the propelling power, with the nature of the tubes, and with the greater or lesser inequality of their internal surface. In these experiments, it appeared, moreover, sufficient to compress any point of the

tubes, in order to increase the sound very considerably. The sound, which was thus produced at pleasure, increased in intensity with the greater sonority of the walls of the tubes, and with the stronger friction of the fluid against these walls, caused either by an augmented rapidity of the fluid, or by an increased inequality of the surface, or, finally, by a stricture, narrowing the diameter of the tube. It naturally followed from these facts, that the sound is the resnlt of the friction of the liquids against the surface of the tubes, and of the subsequent vibrations of their walls.

These conclusions are applicable to the mechanism of the production of arterial sounds, for the physical conditions are nearly the same. The arteries represent the tubes, the blood, the fluid, and the heart the moving power; and we are thus led, by analogy, to explain the arterial sounds by the friction of the blood against the internal surface of the vessels, and by the vibrations of their walls; and as the walls are not very sonorous, the lateral friction may be definitely considered as the principal cause of the sound.

But the differences, which exist between inert tubes employed in the experiments, and between the elastic and contractile canals, which the blood traverses, should modify the explanation to a certain extent; because several conditions belong to the latter, which are absent in the former, as, for example, the curvature of the arteries, the numerous angles formed at the points of division of the vessels, which very materially increase the friction. There exists, moreover, in the arteries, as M. Vernois observes, a vital contractility, which causes their reaction on the blood; and M. Vernois, relying on the fact, that experimenters were not able to produce blowing by diminishing the quantity of the injected liquid, (when the impelling force remained the same,) concluded, that this vitality of the vessels must be taken into account, and "that the energetic reaction of the walls on the blood is of some moment in the production of the sound."

M. Vernois, keeping in mind the opinion of pathologists, who attribute the sounds of the heart to the molecular collision of the blood, and the observation of Haller, confirmed by M. Magendie, that during the circulation of the blood through the vessels, "the globules of the centre move more rapidly than those at the circumference," is led to the belief, that this whirling motion of the molecules contributes to the manifestation of the sound.

We also believe, that it is not a single cause, which pro-

duces the sounds of the arteries, and that, as in the case of the sounds of the heart, several elements contribute to their manifestation, in unequal shares. These elements are, in our opinion, the following: 1st. Lateral friction of the blood against the arterial walls, friction increased by the curvatures and angles of the sub-division of the vessels, and probably, also, by the reaction of the arteries: 2d. The vibrations of the walls, which is, however, of little moment, as their resistance is inconsiderable; and we may, perhaps, add the molecular collision of the blood, which is also more increased on a level with the angels of the vessels. We thus understand, why the sounds are unequal in the two carotid arteries, and more intense in the right, where the angles form a greater impediment, than in the left; why their loudness, which is equal in both crural arteries, increases, when stretching the thigh adds to the tension of the vessel, gives it the arch of the pubis for support, and multiplies the vibrations of the walls.

§ III. Pathological Phenomena.

The arterial sound undergoes, in the morbid state, modifications in intesity, tone, and character: at one time this sound, which is naturally dull, becomes more distinct, and is transformed into single blowing, (intermittent blowing, blowing with a single current); at another it is changed into a more continuous blowing, where we distinguish two sounds, which succeed one another very rapidly, (continuous blowing with a double current), and this new sound, which is then sometimes of a higher and more sonorous tone, has received the name of humming top sound, (bruit de diable); finally, at another time we hear musical sounds variously modulated, called the chant of the arteries.*

Sound of Blowing.

Characters.—This sound, likewise termed the sound of intermittent blowing with a single current, is, in fact, a mere exaggeration of the normal sound; it conveys to the ear the sensation of gentle blowing, analogous to that produced by pressing slightly with the stethoscope on the carotid artery. Single blowing is repeated at equal intervals, at the moment of arterial diastole. It is more or less prolonged,

* See note 3 K.

offers a variety of shades, and its loudness is generally proportional to the volume of the artery, and to the rapidity of the circulation; it is also twice as often met with in women as in men, and more commonly observed in the carotid arteries, than in the crural (: : 5 : 2), and in both sexes it is more generally audible in the arteries on the right than on the left side, (: : 3 : 2, Vernois).

Usually permanent, it ceases sometimes at intervals, so as to reappear at indefinite periods, and under the influence of variable causes; this versatility of the phenomenon is more peculiar to the carotid than to the crural arteries. At one time it coincides with cardiac blowing, at another, on the contrary, abnormal sounds exist only in the vessels, either exclusively in one carotid artery or in both, or at the same time in other large branches of the circulatory apparatus.

In some cases the blowing of the arteries becomes harsh, and constitutes a sound of grating. It is then, in particular, accompanied by vibrating tremors, sensible to the hand.

Physical cause.—Arterial blowing is sometimes only the propagation of blowing occurring in the heart; but, at present, we speak merely of that species of blowing, which has its origin in the arteries. It arises when any cause whatever exaggerates the friction of the blood against the internal surface of the vessels; accordingly, an alteration in the organ traversed by the fluid (internal stricture, inequalities on the internal surface, a pressure imparted externally), or a considerable increase of the power projecting the blood, are pathological conditions capable of occasioning a more intense friction. And these two classes of causes are here, as in the case of the heart, often combined, for a morbid condition, which of itself would not have been able to produce the abnormal sound, reveals it by its connection with another cause.

We easily understand why there is an excess of friction in the cases just mentioned; but blowing occurs sometimes in diseases with alteration of the blood, in plethora, anemia, chlorosis, &c., and it is then difficult to explain it by a similar mechanism. We understand, to a certain extent, the possibility of this friction in the case of plethora, where the vessels are very full, and their walls in a state of greater tension, and therefore more capable of vibrations; add to this, that the circulation is sometimes more rapid, and the power which propels the blood, more intense.

The explanation of anemia and chlorosis is more compli-

cated; anemia, says M. Vernois, occasions "an active contraction of the walls upon themselves, in consequence of which the internal surface of the vessels becomes corrugated, and thus form an additional obstacle to the course of the blood." Physiologists generally admit the existence of this contraction, and, taking this fact for granted, we can understand the possibility of the internal membrane being thrown into folds. In a case of obliteration of the abdominal aorta, published by one of us, (*Arch. de Med.*, 1835,) the large arteries, situated below the obliterated vessel, which had undergone a diminution in their caliber, presented over the internal surface, longitudinal wrinkles and folds.

But what is tbe cause of the sound in chlorosis? Several explanations have been offered, but in every one of them blowing is taken as the effect of increased friction. Accordingly M. Beau has of late looked upon chlorosis as a polyhemia, or aqueous plethora. M. Vernois has in some cases admitted an infiltration of the sub-serous tissue of the endocardium, and of the internal membrane of the arteries on a level with the angles of division; finally, he imagines that there sometimes exists a nervous spasm of the arteries, analogous to that of the urethra during the act of coition, which contracts the walls and produces folds on the internal surfaces.

Pathological signification.—In all these cases, whatever the real mechanism of the arterial sound may be, its morbid signification is better known to us. This blowing indicates an *organic stricture of the artery*, caused, on the one hand, by fibrous or albuminous deposits in its interior, (arteritis) on the other, by contraction of the walls; or, finally, by the formation of osseous or cretaceous deposits, which protrude from under the internal membrane. It is likewise heard in *aneurism* or *arterial dilatations*, and when any species of tumor, situated on the course of the vessel, compresses it. It is, besides, allied to some alterations of the blood, (anemia, chlorosis, cancerous, or tuberculous cachexia, &c.)—Add to this, that there are circumstances in which arterial blowing is but a *phenomenon of transmission*, or nothing else than the propagation of an abnormal sound, which originates in the heart, and the manifestation of which is connected with strictures or insufficiency of the aortic orifice, or also with diseases of the heart itself.

When blowing is the result of a local disease, such as stricture, aneurism, external tumors, etc., it occurs most gen-

erally only in the affected vessel, or at most in the contiguous large branches. On the other hand, it tends to distribute itself over a greater or lesser number of arteries, when it depends on alterations of the blood. If it be merely a phenomenon of transmission, it is commonly limited to the large trunks, springing from the arch of the aorta, and sometimes it is only audible in the left carotid artery. This difference in seat, is, moreover, less developed, when blowing depends on insufficiency of the aortic valves; cardiac blowing may then be propagated not only into the left, but also into the right carotid artery, into the sub-clavian, and even into more remote arteries. In those cases, where it is developed under an accidental influence, it is characterised by its intermittence and sudden re-appearance or cessation, according as the cause, which disturbs the mechanism of the circulation, continues or ceases to act.

C. *Sound of Continuous Blowing, and Humming Top Sound, (bruit de diable.)*

According to M. Bouillaud, who has minutely examined these stethoscopic phenomena, the *sound of continuous blowing*, (*bellows-sound, with a double current*,) *and the humming top sound*, are only varieties of one another, the latter being more acute than the former.

Continuous blowing is distinguished from that already described, by its being formed of a double sound instead of a single one, for every pulsation of the heart; the first coincides with arterial diastole, and is louder than the second, which accompanies arterial systole; and as they succeed one another almost without any interruption, an apparently continuous sound arises from it, which increases however, during arterial diastole. It is in general loud and full, and presents various shades in tone and intensity; when its intensity is very feeble, and its tone very low, it resembles the sound of a pair of bellows; but, in proportion as it increases in loudness, it approaches the sound produced by spinning the top, called, in the language of children, *the devil;* and, in the same manner as the sound of this toy becomes more and more sonorous and resonant, the more rapidly it turns, so we may recognize the *humming sound in the arteries*, with different shades of intensity and resonance. This comparison is very exact; for, in like manner as the humming of the top, though continuous, becomes louder and shriller with every

additional lash of the whip, so the arterial humming sound is augmented and increased in shrillness at each ventricular systole, which agitates and *lashes*, if we may say so, the arteries.

The arterial sound is sometimes more analogous to the cooing of a turtle-dove, or to the whistling caused by the air rushing through the crevices of a door; it is then gradually transformed into musical sounds, of which we shall speak afterwards.

"The humming top sound has its favorite seat in the carotid and sub-clavian arteries; we hear it at the point of its maximum intensity on applying the stethoscope above the internal portion of the clavicle." It is less common, and always less developed in the crural arteries. Most frequently it exists but on one side, and when it occurs on both at once, it is never so intense on the right as on the left. It is sometimes permanent, but more frequently intermittent, and is reproduced as suddenly as it disappears, without our being able to allege any satisfactory reason for these abrupt and irregular alterations. If we press with the stethoscope on the course of the artery, the humming top sound is in some cases sensibly diminished, whereas in others it is transformed into a species of lowing and grumbling, which is almost painful to the ear.

The changed position of the neck influences likewise the intensity of the sound, which commonly increases, when the head is turned backwards and to the opposite side, from that, which we examine. If we remove the larynx from the artery, the sound diminishes suddenly, or disappears even entirely (*Bouillaud.*) If, as M. Donné has first observed, the patient makes a prolonged effort, the humming top sound is at that moment suspended, like the sound of a chord, the vibrations of which are arrested by pressure. Moreover, the sound ceases immediately, if we compress the artery so strongly as to interrupt the circulation.

The humming top sound co-exists often with a sound of blowing during the first third; but M. Bouillaud has never heard a sound at the precordial region, exactly similar to the humming or whistling of the arteries.

Physical causes.—Though the sound of blowing with a single current is easily explained by the friction of the columns of blood, propelled by ventricular contraction, the case is different in blowing with a double current. We hold, that we should here attribute, to the reaction of the arterial

walls against the blood, a considerable share in the production of the phenomenon; and if the resonance of the systolic sound depend principally on the propulsion of the column of blood, might not the sound which continues during the systole of the heart be owing chiefly to arterial reaction, and to the retrograde motion, which it imparts to the fluid? The reality of this influence appears to us the more probable, because the humming top sound occurs almost exclusively in the carotid arteries, where the retrograde motion is also most developed.

The proximity of the heart seems to be a new condition for developing the resonance of carotid blowing, because the shock of that organ is more strongly communicated to the carotid, than to the crural arteries. May not the neighborhood of the larynx and the trachea, likewise, account for this resonance, since these tubes act then in the capacity of sounding boards, which are capable of reinforcing the sounds, as in certain musical instruments? What tends to prove this, is, that it often suffices to remove the air tube, in order to diminish, or even to annihilate the humming top sound. Might not the whirling motion of the molecules of the blood, constitute the final cause of the production of the sound? We can at least scarcely avoid admitting, that the nature of the fluid, which traverses the arteries, exerts a powerful influence over the manifestation of the phenomenon, as it appears only in those cases, where the blood undergoes a particular change, and when its intensity diminishes in proportion as, by appropriate regimen and treatment, we restore to it its lost qualities.

Pathological signification.—We now know, thanks to the researches of M. Bouillaud, that continuous blowing, and its varieties, are essentially, if not exclusively connected with a general condition of the animal economy, with anemia, or at least with such a state of the blood, where the serous portion predominates over the coloring and fibrous portion, (*hydremia.*) These varieties are, like intermittent blowing, met with in anemia, which is either constitutional, or consequent upon spontaneous hemorrhagies, or upon excessive sanguineous depletion; but they seem more than the other, to belong especially to *chlorosis.* When this particular alteration of the blood is little developed in hysterical women, or in pale, nervous, delicate, and truly chlorotic persons of the male sex, continuous blowing is not very intense; when, on the other hand, chlorosis is well characterised, *the humming top sound* becomes generally audible.

We shall now understand the semeiological value of this humming sound, if we recollect, that there are certain cases of chlorosis, where the diagnosis is really difficult, and that most physicians deceive themselves by attributing to an organic disease of the heart, the palpitations, the state of oppression after the least exertion, the slight œdema of the ankles, or the swelling of the face, &c., which characterise an advanced stage of chlorosis The perception of the humming top sound in the carotid arteries (we have never recognised it in an organic affection of the heart) will dispel all doubts, and change completely the therapeutic indications.

Musical Sounds.

In some cases the abnormal sounds of the arteries exhibit a truly musical tone. Laennec and M. Bouillaud, have described this phenomenon under the name of *sibilant blowing*, *melodious blowing*, or *chant of the arteries;* they have considered it as a transformation of the arterial sounds of blowing. M. Vernois, on the other hand, arranges the musical sounds into a completely distinct class, and founds his opinion on these two considerations, that it is impossible to produce them artificially, and that in 90 cases observed by him, he has met with them 69 times unaccompanied by sounds of blowing, and without any coincidence with them.

Characters.—The musical sounds constitute "a regular chant, variously accentuated, running through several octaves, and passing successively from more acute to deeper sounds," which Laennec has tried to write down in notes, an attempt, which generally proves abortive, for they are too variable to disclose any measure or rhythm peculiar to these accidental successions. They have been compared to the sounds of the Jew's harp,—to the buzzing of an insect, (*sound of flies*,) to the snoring sound of the air in a shell, or in an accoustic trumpet,—to the resonance of the tuning-fork, to the whistling of the wind through a key-hole, to the prolonged vibrations of a metallic chord. "In general," says M. Bouillaud, (P. I. p. 116,) "the monotonous air, which the arteries whistle, is somewhat plaintive and mournful. The sounds, which compose it, become increased and shriller at the the moment of ventricular systole; and during the interval, which separates one systole from the other, it continues, though less intense. The melody is heard to move generally in this double strain. In some cases the sounds increase, both

during vintricular systole and during arterial systole or reaction, but they seem lower during the repose of the artery." Whatever may be the character of these sounds, they occur with variable degrees of intensity.

The musical sounds, which are far less common than blowing, (as 1: 6) have been observed by M. Vernois, in the carotid, sub-clavian, and crural arteries; but, like blowing, they are more rarely met with in the crural than in the carotid arteries, in the proportion of 1: 17, which gives a more distinct difference than in the case of the sound of blowing.

They occur also twice as often on the right as on the left, and are in general more frequently observed on one side than on both at the same time, (: : 4: 1).

Contrary to what happens in blowing, they are more commonly intermittent than continuous, and they appear, vanish, and reappear, within a very short period, and in a very irregular manner.

They are much more common in woman than in man (: : 17: 1), and M. Bouillaud has noticed them especially in lean persons of the female sex, whose arteries are little developed. The presence of the menses favors the production of the sounds, and moral emotions seem to have the same effect. (Vernois.)

Musical sounds may alternate with blowing, but most frequently they occur alone. They are, besides, often accompanied by vibratory tremors of the arteries, and these tremors are, according to M. Bouillaud, more diffuse and somewhat less harsh, than those produced in certain strictures of the orifices of the heart.

Physical cause and pathological signification.—In the present state of science, we might, says Bouillaud (*ibid.* p. 159,) assign to the musical sounds, several physical causes; but it is as yet difficult to determine precisely their respective value. In order to decide this question, M. Vernois states, that musical sounds have never been produced by experiments made with inert tubes, and that they are chiefly observed in irritable persons, or under particular conditions of excitement; he has indeed noticed them seventeen times more frequently in woman than in man, never in the crural arteries of the latter, and the five females, who exhibited the musical sounds in the crural arteries, were at the period of menstruation; by confronting this fact with the other consideration, that the musical sounds do not exist unless we apply the stethoscope, he concludes that these phenomena, are not the result of

purely physical causes, and he attributes them to an accidental spasm of the arterial walls, caused by the application of the cylinder, the presure of which combines with the other elements already alluded to, in the production of the sound.

Whatever may be the value of these explanations, the musical sounds are of the greatest importance in semeiology, because they are constantly allied with alterations of the blood, and especially recognized in chlorosis and constitutional anemia.

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SECOND SECTION.

AUSCULTATION OF THE ABDOMEN.*

The auscultation of the abdomen comprises the examination both of the stethoscopic signs furnished by the organs, which are contained in the cavity of the abdomen, and of the phenomenon of gestation: We shall, in the sequel, treat separately of obstetric auscultation, that we may not, at present, interrupt the discussion of the *signs characteristic* of disease.

In order to explore the abdominal organs, the patient should place himself symmetrically in the dorsal posture, with his thigh slightly raised, and his knees moderately relaxed. It is sometimes requisite to incline the body laterally; and, in some rare cases, to place the individual on his hands and feet, with the view of ascertaining if, by a change of posture, certain sounds alter their seat, become modified, or cease to be heard. The abdomen should be left bare, or covered with a thin garment, which causes no friction.

The physician places himself near the side he wishes to examine; according to the nature of the phenomena and of the organ he intends to explore, he employs the ear or the stethoscope, and the latter is generally more advantageous, as it enables him to depress and isolate soft and pliant parts, and get at those more deeply situated. Immediate auscultation is, perhaps, preferable for appreciating peritoneal friction, but the cylinder is of greater service for the examination of the abdominal aorta, the bladder, &c.

We associate, sometimes, percussion with auscultation, in cases of acites, of tumors containing hydatids, &c., occasionally we exercise, simultaneously, a pressure on the affected region, for example, on the kidneys, in order to produce collision between several calculi.

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* See note 3 L.

Peritoneum.—On examining any region whatever of the abdomen, we hear only a species of gurgling, which is owing to gas traversing the digestive canal. The displacement of the organs caused by contractions of the abdominal muscles, by the descent or the elevation of the diaphragm, by the peristaltic motion of the intestines, is silently accomplished, on account of the small extent of these changes of position, on account of the little resistance offered by the contiguous surfaces of the organs, and, above all, on account of the smoothness of the surfaces, lined by the peritoneum.

In some morbid conditions we hear a particular sound, termed *peritoneal friction*. M. Piorry (*De la percussion méd.* 1838, *p.* 174,) ascribes to Laennec the discovery of this phenomenon.* In June, 1834, M. Després proclaimed, in a communication laid before the Anatomical Society, "that, in the first stages of peritonitis, and previous to the formation of an effusion, a sound of the creak of leather, or of friction becomes audible, which is analogous to that generally associated with pericarditis." More recently, Dr. Beatty of Dublin. (Arch. gen. de Med., T. VI., 2d series, p. 431,) and afterwards Dr. Corrigan, (Arch. gen. de Med. 2d series, T. XII., p 226–235,) and Dr. Bright, (Med. Chir. Transact. T. IX,) have more amply described the phenomenon, and M. Després has made it the subject of his Inauguration Essay, (Thes. de Par., avril 1840.)

Peritoneal friction, which is of rarer occurrence than pleuritic friction, conveys to the ear, like the latter, the sensation of two rough surfaces gliding over one another, so as to cause a friction-sound. Its intensity is variable, and its two extremes are a scarcely perceptible sound of rustling, and of harsh rasping, appreciable both by the ear and by the hand.

The mechanism of its production is identical with that of pleuritic or pericardial friction; in other words, it requires for its manifestation several conditions, for example, the existence of two rough surfaces, their reciprocal contact and gliding motion; finally, a resistance strong enough to render the sound tolerably intense. The rare combination of these circumstances, accounts for the unusual occurrence of the phenomenon. Indeed, as the contiguous organs are almost all soft and yielding, there seldom exists a solid fulcrum, upon which the sound of harsh friction may be elicited; and, besides, in acute peritonitis, the pain restrains or impedes the motions necessary for

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* See Note 3 M.

the manifestation of the sound, and in chronic peritonitis, the adhesions, which have been forming, oppose the gliding motions of the surfaces in contact.

Peritoneal friction is only perceived in *some cases of peritonitis*, and especially in *tuberculous peritonitis*, because the tubercles, disseminated over the false membranes, form more considerable and harder protuberances. It becomes still more sensible, when partial peritonitis occupies a special seat, when, for example, the pseudo-membranes line the convex region of the liver, and the inferior surfaces of the diaphragm, because these surfaces offer greater resistance, and execute a more intense friction, as they are under the influence of the dilatations of the chest; the same takes place, when the morbid deposits cover entirely full or solid substances, such as tumours of the uterus, the ovaries, &c.

It follows from this, that peritoneal friction may be considered as an additional sign of the symptoms of peritonitis; but its absence does not prove the non-existence of that disease, and the rare occurrence of the phenomenon detracts greatly from its value.

There are, however, cases, where the friction may become a sign, capable of guiding the practitioner in the diagnosis, and in the treatment of some affections, situated on the interior or exterior of the cavity of the peritoneum. Suppose that we intend to open an abscess, or a tumour containing hydatids in the liver, and that by the method of M. Recamier, we have tried to produce, artificially, between the tumor and the walls of the abdomen, adhesions, without which the operation could not be safely accomplished; the manifestation of local friction would then be a favorable sign, as it indicates the process of exudation which precedes the formation of adhesions; and its cessation, after the lapse of some days, would imply, that the adhesion is complete, and that the surgeon may now open the tumour without fear of causing an effusion into the cavity of the peritoneum. Again, in the case of ascites, if, previous to the act of puncturing the abdomen, peritoneal crackling be perceived at the place selected for paracentesis, the surgeon should choose another point, lest he plunge the trochar into an intestine in contact with the abdominal wall.

"Finally," says M. Després, (loc. cit. p. 26.) "the accurate study of peritoneal friction will sometimes throw a light on the treatment of strangulated hernia; every surgeon knows how important it is to assure himself in some cases, whether

the patient laboring under irreducible hernia, be affected with peritonitis, or whether the symptoms it presents be produced by a strangulated state of the intestines, owing to the hernia. By means of peritoneal friction, we may sometimes determine, whether there exists peritonitis or not, as this phenomenon is developed simultaneously with the first symptoms of colic, and continues a very long time."

Stomach.—The stethoscope applied to the region of the stomach, reveals sounds, which depend on the motions of gas in this intestine. We sometimes perceive a species of *metallic tinkling*, allied with the presence of gas and of liquids contained in the cavity of the stomach. Under these circumstances, the succussion of the abdomen gives rise to a *sound of waves*, which is also discernible at a distance. When this sound is only transient, it is of almost no value, as it may shew itself in debilitated persons, independent of organic disease; (Piorry,) but when it persists for some time, and becomes manifest after digestion, it indicates, that the stomach is enlarged, that its walls are kept in a state of continual distention, as we observe in strictures of the polyrus; and the *sound of waves* furnishes then an additional sign of this serious disease.

Intestines.—On examining with the ear along the course of the intestines, we hear only a species of grumbling. Auscultation has as yet been applied with profit only to cases of hernia; if, in the case of a hernial tumour, an audible grumbling be produced under the pressure of the fingers, it is a sure sign of enterocele.

Liver.—"I imagine," said Laennec, (T. III. p. 534,) "that the stethoscope is able to disclose an abscess in the liver, and hydatid cysts formed in this intestine, when they open into the stomach, the intestines, or the lung, examples of which have been seen. In the two former cases, by pressing the stomach at the soft portion of the right hypochondria, we may obtain a manifest sound of grumbling, owing to the introduction of the intestinal gas into the excavation of the liver. In the latter case, namely, when there exists a fistulous communication between the abscess of the liver and the bronchiæ, cavernous cough and respiration, as well as cavernous râle, will be heard; and, perhaps, even the transmission of the voice through the tube of the cylinder, nay, if the excavation be very large, metallic tinkling will most probably take place."

But auscultation is not only of service at that advanced

period of the affections of the liver; it also assists sometimes in the diagnosis of various kinds of tumours at the hepatic region, which have no communication with the digestive organs, or with the air passages; it may thus contribute to reveal the existence of a cyst containing hydatids, by causing the ear, as well as the hand, to perceive a species of particular tremor, produced by the collision of the acephalocystes. The intensity of the sound, its degree of proximity, indicates whether the cyst is near or at a distance from the convex surface of the liver, and will consequently enlighten us as to the possibility of treating it by the bold operation proposed by M. Recamier, which, in his skilful hands, has been crowned with success. Auscultation assists, likewise, in disclosing simple changes in the volume of the liver, as it enables us to determine with accuracy the limits, which separate it from the organs of the thorax. Indeed, if, in the absence of the signs of pulmonary diseases, and without displacement upwards of the inferior hepatic edge, we recognise at the base of the chest, and on the right side, silence of the respiratory murmur, which extends farther up than usual, we ought to conclude, that the liver is hypertrophied.

Finally, in some cases of biliary calculi, on placing the stethoscope (at the same time that we exert pressure) upon the region corresponding to the gall-bladder, we may possibly hear a crepitation, produced by the friction of the calculous concretions against one another. M. Lisfranc, who has first adverted to this fact, (*Mem. sur de nouv. applications du stethoscope, aout* 1823,) has succeeded in eliciting this sound of collision in an individual, whose liver projected below the false ribs, and where several calculi were found on inspection in the gall-bladder.

Spleen.—Auscultation has taught us nothing in regard to the affections of the spleen; except that in some cases, where the question arises, whether this organ be increased in volume, it might serve (less accurately, however, than percussion,) to determine its superior limits, by informing us, that respiration is heard not so low down as usual, in the vicinity of the spleen.

Kidneys.—May auscultation be of service for the diagnosis of some affections of the kidneys? We can take for granted, that in a case, where many calculi are brought into mutual contact in the pelvis of the kidney, a pressure imparted by the hand to the corresponding lumbar region, elicits a sound of friction, which is owing to the asperities of

these concretions; but this is a fact, which experience has not yet sufficiently verified. We make the same remark, as regards renal fistula; which, communicating with the exterior, permits the introduction of the air, and the manifestation of particular stethoscopic phenomena, or the exploration with a probe which, on encountering the calculi, would, by its concussion, give rise to the production of a sound.

The bladder.—M. Lisfranc, in his memoir on the application of the stethoscope to several surgical affections, has pointed out the services, which auscultation might render to the investigation of calculi in the bladder. "In order that the cylinder may furnish more distinct sensations," says M. Lisfranc, (*loco cit.* p. 28,) "we apply it to the body of the pubis, and to the posterior portion of the sacrum; if the catheter be then introduced into an empty bladder, which contains no calculi, the regular movements imparted to this instrument, occasions sounds analogous to those of a pressure-pump in action. If we introduce soft substances into the bladder, the stethoscope furnishes no other data than those just mentioned. But whenever there exists a calculus, an extremely distinct sound of clapping, or rather a sound similar to that elicited by the action of a file upon a hard substance, becomes audible. These sensations are produced by the slightest motions of the catheter."

M. Moreau de Saint-Ludgère, (Thèses de Paris 1839) following out these indications, produced and confirmed by Laennec, has attempted to render the auscultation strictly *immediate;* and for this purpose he proposed to attach, by means of a piece of cork, the disk of the stethoscope to the handle of a metallic sound. In this condition the instrument is introduced into the bladder; we examine by applying the ear to the disk, and the sounds are thus conveyed directly to the ear of the observer.

Whatever may be the method employed, we obtain a tolerably correct idea of the degree of solidity of the concretions, of their arrangement, of their mobility, and, perhaps, even of their number, from the character of the sound manifested by the shock of the catheter against the calculi.

It is thus possible to establish a sure diagnosis by the aid of auscultation, and we shall avoid confounding a fungus or a soft tumor of the bladder, with a calculus concretion. We shall also escape those fatal errors, sometimes committed by surgeons, of operating on individuals, whose bladder contained no calculi.

The uterus and ovaries.—Auscultation applied to the uterus, reveals in pregnancy important signs, of which we shall speak hereafter. In diseases, it furnishes no other phenomena than the sounds of blowing, which occur in the large vessels behind the uterus, and which depend on the compression exercised by that organ, when it is the seat of tumors of various descriptions. The stethoscopic exploration of the ovaries might, in cases of ovarian pregnancy, reveal pulsations of the heart of the fœtus. "Let us not forget," adds M. Piorry, (Traité de diagn. T. II. p. 57,) "that some tumors of the ovary containing large vessels, or being partially the seat of a very active circulation, or compressing voluminous arteries, may exhibit the sound of blowing, and that it is important not to mistake it for that produced by the placenta, or by an aneurism.

Large vessels of the abdomen.—Finally, on examining the different points of the abdomen which correspond to the large vessels, we hear, sometimes, a confused noise or blowing, which depends either on aneurisms of the aorta, of the iliac arteries, etc. or on compression exercised by the organs themselves, (uterus, liver, etc.), or by tumors of different descriptions.

THIRD SECTION.

AUSCULTATION OF THE HEAD.

CEREBRAL DISEASES.

No one had thought of deriving, or at all events, no one had successfully attempted to drive from the discovery of Laennec any diagnostic signs for *diseases of the brain.* Lately, Dr. Fisher of Boston, (*the Med. Magazine, No.* 5, *and Gazette méd.*, t. II. No. 2., January 1834), intimated, that the idea having occurred to him of applying the ear and stethoscope to the surface of the cranium, he had discovered an *encephalic bellows-sound*, in children laboring under acute or chronic affections of the meninges, and in cases of inflammation of the brain. This sound of blowing, synchronous with the arterial pulsations, was every where discernible, but much more distinct above the anterior extremity of the sagittal fissure.

Dr. Fisher continuing his enquiry, examined the head of a certain number of individuals, of all ages, and arrived at the following conclusions:—1st. The encephalic bellows-sound does not exist in the normal condition. 2d. We should distinguish it (and the distinction is easy) from the other sounds, very distinctly perceived in the auscultation of the head; from the sound of the air, which penetrates the nasal fossæ, from that of deglutition, and of the voice, and even from the sound of the heart. 3d. Encephalic blowing originates in the arterial trunks, at the base of the cranium, when they are compressed by the brain; this happens, whenever this organ is subjected to pressure by a liquid effusion, or increased in volume by an inflammatory engorgement. The caliber of these arteries is then diminished, the blood circulates with greater difficulty, and it is to this impediment in the circulation, and to the excess of friction resulting from it, that we should attribute the production of

the sound. 4th. This sound of blowing announces a state of engorgement, or compression of the encephalic organs.

The American physician alleges having met with this abnormal sound in several cases of hydrocephalus or encephalitis, in children suffering from dentition, and in two young patients affected with hooping cough, but only at the moment the choking-cough ceased, and whilst the accumulation of the blood towards the head was still evident, from the redness of the face.

Dr. Fisher has in a more recent work (American Journal of the Medical Sciences, August 1838,) published new results in support of his first researches; and he assures us of having heard the sound of encephalic blowing not only in the affections just mentioned, but also in several cases of apoplexy and fracture of the cranium.

Without questioning the reality of these facts, we remark, that since Dr. Fisher's first publication, no French observer has yet corroborated these results. Neither M. Bouillaud nor M. Andral mention encephalic blowing. M. Vernois says that he has frequently, but always ineffectively, examined from eight to ten cases of meningitis; and he adds, that Dr. Stillé, a former resident clerk of the Hospital of Philadelphia, has learned from Dr. Fisher himself the method of recognising this sound, but that, during two years observations, he has not succeeded in discovering it. We have ourselves carefully examined seven or eight cases of meningitis over all the regions of the cranium, but have looked in vain for the phenomena in question. Like Dr. Fisher, we have easily recognised the sounds produced in the nasal fossæ, those of deglutition, &c. but have heard nothing analogous to a sound of blowing. However this may be, auscultation applied to the diseases of the encephalon is a new field opened to observers, and the success of their attempts will be the more gratefully acknowledged, because the diagnosis of the cerebral affections, notwithstanding the important labors of several modern pathologists, is still very difficult.

*Diseaseases of the Ear.**

"In the normal state, the internal ear contains air, which penetrates into it through the Eustachian tube, and is renewed without our becoming conscious of this movement.

Note 3* See N.

The air arrives slowly and insensibly at the internal ear, especially during the act of deglutition, and, on examining the ear and the mastoid region, we perceive no sound indicative of this introduction of the air into those cavities, all the walls of which are inelastic, with the exception of the membrane of the tympanum.

When there exists, on the other hand, disease of the Eustachian tube, for example, a condensation of the mucous membrane which lines it, the passage of the air is then impeded by an obstacle; and this fluid being retained in the cavity, and left in want of a fresh supply, becomes rarefied by means of heat and moisture emitted from the surrounding parts. If we succeed in removing this obstacle, either by catheterism of the tube, or by a violent effort of exspiration during closure of the nose and mouth, we hear a very remarkable sound, with the following characters.

"A considerable quantity of air introduced into the cavity of the tympanum, occasions a *sound of simple blowing*, which is somewhat shrill, when there exists no accumulation of mucus in the internal ear. This sound is generally accompanied by a slight *clapping*, a species of fine and dry crepitation produced by the tympanum, which is pushed outwards by the air, and loses part of its concave figure. The examination of this membrane at that very moment discloses it in the state of being pushed outwards and variously furrowed."

When the cavity is more or less filled with mucus, the air, on traversing this moist secretion, occasions a sound of sonorous *subcrepitating* râle, which is more or less intense, and may even amount to *gurgling*. This moist râle presents a great variety of shades, depending on the quantity of matter contained in the cavity, on its degree of viscidity, &c. When the cavity is perfectly dry, as is the case in many individuals who have become deaf in consequence of chronic tinkling, the sound of blowing assumes the form of shrill whistling; and we hear, moreover, a dry resonance, produced by the tremors of the tympanum, which is rendered thin and friable."

"When the membrane of the tympanum is perforated, all these sounds become audible at a greater or lesser distance, according to the degree of permeability of the tube. This mucous and whistling sound is sometimes obscured by ringing vibrations, caused by the edges of the tympanic fistula; but in general these various species of sounds may be easily distinguished."

"With the greatest care, I have never been able to hear any sound in the mastoid cells, even when a considerable quantity of muco-purulent matter, which issued from the internal ear, indicated, in accordance with other symptoms, that inflammation had affected those cavities."

"I may say, that we hear, without difficulty, all the sounds proceeding from the summit of the pharynx, on applying the ear to the lateral portions of the head and face. Accordingly, when a probe is introduced through the nasal fossæ, up to the superior portion of the pharynx, beyond the cartilaginous edge of the Eustachian tube, it generally encounters a certain quantity of mucous; on drawing a breath, a sound of gurgling is then perceived by the stethoscope at the external ear, which might be mistaken for a sound originating in the cavities of the ear. But as the sound is heard with equal distinctness at the nasal fossae and at the mouth, we cannot be misled as to the real seat of the phenomena."

Let us conclude our remarks on the auscultation of the head, with the following paragraph from Laennec: "The stethoscope, applied to the superciliary protuberances and to the root of the nose, reveals the penetration of the air into the frontal and ethmoid sinuses. On applying the instrument to the superior dental arch or to the cheek-bone, we hear the air enter into the maxillary sinuses. We have therefore a right to think that the stethoscope may furnish useful signs for several diseases of those cavities, and especially for mucous or purulent collections."

FOURTH SECTION.

AUSCULTATION APPLIED TO THE LIMBS.

Diseases of the Vascular System.

In cases of *aneurisms of the limbs*, auscultation furnishes, as in those of the aorta or of other arteries situated within the large cavities, valuable signs for our diagnosis. At one time the stethoscope reveals a simple pulsation, much more intense, than that in the normal state, at another a sound of blowing or grating; finally, at another time we perceive a tremulous and humming sound. These differences in the acoustic phenomena, depend on the condition of the vessel, of the aneurismal sac, and of the communicating aperture.

We may easily form an estimate of the utility of those signs in some cases, where the diagnosis is doubtful, from absence of the phenomena furnished by the eye and the touch, whether it be because the aneurism lies deeply buried, is surrounded by thick walls, and almost obliterated by fibrous deposits, or because the limb is infiltred, swollen, or that acertain quantity of blood is, in consequence of the rupture of an artery, effused into the contiguous cellular tissue.

Under some circumstances auscultation is equally useful by its negative results, as in the absence of all stethoscopic phenomena, it may serve to distinguish from aneurism any other tumor, which, situated in the neighborhood of the artery, exhibits the appearance of pulsations and jerking.

In *aneurismal varix*, as well as in some other species of aneurism, the hand feels a tremulous motion, and the ear perceives a sound of humming and whistling, (*sibilus*, Sennert,) which is, undoubtedly, produced by the current of arterial blood through the aperture of the vein.

It also happens, sometimes, that we hear a sound of blowing in erectile tumors. We have observed, in a patient at the Hotel Dieu, two tumors, the one in front of the sternum, and the other at the upper end of the left arm, formed at the expense of the external portion of the humerus. Both exhibited a distinct jerking motion, synchronous with the pulse, and a movement of expansion, accompanied by tremors discernible by the touch; during each jerk or elevation, auscultation revealed a sound of very intense blowing. These tumors were, on inspection after death, discovered to be of an encephaloid nature, containing vessels and slight effusions of blood.

Diseases of the Soft Parts, of the Articulations, and of the Bones.

M. Lisfranc had, in his memoir, pointed out the useful application of the stethoscope for discovering *foreign bodies* at the bottom of a wound, (as well as in a natural cavity like the œsophagus, the rectum,) the presence of which is indicated by the particular sound produced in striking them with a probe. Laennec has confirmed the accuracy of that remark: "I have no doubt," he says, "that the various sounds resulting from the shock of the probe against a bullet, the point of a sword, the splinter of a grenade, which are deeply buried close to a bone, or implanted in its substance, give a surer notice of those foreign bodies than the sensations transmitted to the hand through the probe."

The stethoscope assists also, according to M. Lisfranc, in the diagnosis of deep-seated *cysts*, or of those concretions analogous to the kernels of a pear or to the seed of a melon.

Laennec fancied, in his turn, that the stethoscope was prefarable to the probe, in giving us an idea of the situation and extent of *fistula*, and burrowing sinuses, by eliciting, through the medium of injected liquid and air, a sound of gurgling analogous to the râle of pulmonary caverns.

We should also avail ourselves of the method of auscultation, in the diagnosis of the *diseases of the articulations*. This new application, to which M. Lisfranc had alluded, when treating of hydrarthrosis and foreign bodies, has been extended to some cases of articular inflammation. M. Andral (edit. de Laennec, T. I. p. 148,) states, that on imparting movements to the patella, he recognised a friction sound analogous to that of the pleura, in the femoro-tibial articula-

tion of a man, where these parts exhibited all the other signs of commencing inflammation. M. Marjolin has observed a similar fact.

It is also evident, that we appreciate better with the stethoscope, the sounds of crackling produced by erosion of the articular extremities, &c. and we may easily admit, with M. Lisfranc and Laennec, that some *diseases of the bones, necrosis, caries, &c.* are interpreted by particular sounds, perceived with the cylinder at the moment the probe strikes a sequestrum, or a portion of decayed bone, in those cases, where the tactile sensation leaves us in uncertainty.

But one of the most important applications of auscultation, to the diseases of the osseous system, consists in the employment of the stethoscope, for the diagnosis of *fractures;* and we are greatly indebted to M. Lisfranc for those researches, the accuracy of which Laennec has confirmed, and which he has embodied in his work. The following is a short abstract of it:

The stethoscope, placed over a fracture, occasions, on the slightest motion of the limb, a crepitation more manifest than that perceived by the naked ear, during the most extended movements.

In general, the cylinder should be applied over the seat of the fracture; but when the soft parts are too much swollen from inflammation, we should place the instrument over the point of the fractured bone nearest the skin, or even over one of the bones articulating with it, because the crepitation is better propagated through the bones, than through the muscles and the cellular tissue. Accordingly, in the case of fractured neck of the femur, we prefer applying the stethoscope to the great trochanter, or to the crest of the ilium.

Crepitation arising from fragments of compact bones, exhibits a ringing sound; that of the spongy bones is duller, and the ringing sounds are only perceived at intervals. In the case of oblique fractures, the sound is louder than that of transverse fractures; and it is more obscure, if the fractured portions cross one another; when the fracture is comminuted, the stethoscope conveys distinctly the sensation of several separate splinters. The sound decreases in proportion as we remove from the point, where it originates; but it may be heard, especially in fractures of the femur, to a great distance, and as far as the cranium. The precise determination of the seat of the disease becomes in that case a very easy task.

When liquids are effused around the fracture, a species of gurgling is combined with the crepitation. When the fracture is compound, we hear at the same time a sound of blowing, analogous to that accompanying powerful inspirations and expirations, made with the mouth open. It is impossible to confound the crepitation caused by fractures, with the sensation furnished in the case of luxation; this latter sensation is dull and obscure, as if two polished and moist surfaces were gliding over one another.

We remark besides, that the above mentioned characters, may also serve to distinguish the crepitation of a fracture from crackling, which is sometimes produced in the movements of the limbs, by the reciprocal gliding motion of two articular surfaces, or by the friction of a tendon contiguous to an articulation. Auscultation discloses, in a similar manner, the differences between this crepitation, and another depending on partial emphysema of the cellular tissue.

The preceding considerations are of great practical value. The strict application of the precepts given by M. Lisfranc, enables us to establish with ease and certainty, the diagnosis of even doubtful fractures, and, with the aid of the stethoscope, the surgeon will not fail to rescue his patient from the violent sufferings, which other methods of investigation render inevitable.

Obstetric Auscultation.

In the year 1818, M. Mayor, of Geneva, stated, that we might hear through the walls of the abdomen, the pulsations of the heart of the fœtus; this was the first step to the application of stethoscopy to the study of the phenomena of gestation. But that valuable observation remained unknown, until M. de Kergaradec published, in the year 1822, the first work, which has appeared on auscultation applied to pregnancy, and pointed out two phenomena, constituting the most positive signs of gestation.

Since that time, this new application of Laennec's discovery has called forth numerous and important inquiries in Germany, France, and England. We select out of this number a report made to the Academy, by M. Paul Dubois (1832) the monograph of Dr. Hohl (1833) the researches of M. Bouillaud embodied in his *Traité des maladies du cœur* (1835,); those of Dr. Kennedy (*Dublin Hosp. Reports*, T. V.) the thesis of M. Jacquemier (*Thés de Par*. Dec. 1837,) the

article of Dr. Stoltz (*Dict. des études méd*. T. I. Paris, 1838,) the treatise of Dr. H. F. Nægele, on Obstetrical Auscultation (*Mayence* 1838,) and the dissertation of M. Carrière of Strasburg.

More recently, M. Depaul has published the results of numerous statistical extracts, in books upon auscultation, as a means of forming the diagnosis of the presentations and positions of the fœtus, (*Théses de Paris*, *December* 1839). Finally, Dr. Helm has lately added to his treatise on puerpal diseases, an interesting chapter on the auscultation of pregnant women.

Regulations.—The greater number of the precepts explained in the chapter on the auscultation of the abdomen, are here again applicable, and we shall only add a few remarks. The female should lie on her back, her head supported by a pillow, and her arms stretched out by her side, taking care to keep the legs slightly bent, as it favors the relaxation of the abdominal parietes, and allows them to be pressed down, so as to be brought in contact with the uterus. Occasionally the body is inclined towards the right or left side, in order to ascertain, whether the sounds propagate towards the lumbar regions and continue or become modified with the changed position of the matrix; it is sometimes inclined forward, so as to withdraw the arteries of the pelvis from the pressure of the uterus.

The physician may employ the ear for the investigation of the sounds, but in general the stethoscope is preferable, for it enables him to isolate them better from those occurring in the neighborhood, and to determine more accurately their seat, limits, and maximum intensity; moreover, in using the cylinder, we can more easily depress the abdominal and uterine walls, for the sake of approaching the surface of the fœtus.

As the sounds of gestation are generally of mean intensity,—often very circumscribed,—variable in seat, and always, difficult to detect by an unexperienced ear, their examination requires deep attention and silence; it should be prolonged, repeated at different intervals, and the observer should explore, successively, all the points of the abdomen. The common stethoscope suffices for this purpose, and there is seldom occasion for employing, with advantage, the curved stethoscope of M. Nauche, (métroscope,) proposed to be introduced into the vagina, in order to examine the inferior segment of the uterus.

Stethoscopic phenomena.—On examining a female, who is beyond the first half of gestation, we hear several sounds, one of which is evidently connected with the circulation of the mother, (*uterine blowing*,) whilst the others depend on the circulation in the fœtus, (*double pulsations*,) or on its motions in the matrix, (*sounds of displacement of the fœtus.*)*

A. *Uterine Sound.*

Synonymes.—Pulsation with blowing, placental sound or blowing, uterine sound, simple pulsation, &c.

Uterine blowing, notwithstanding the contradictory opinions of some observers, is a phenomenon of very frequent occurrence: indeed it rarely fails during the second half of gestation, and after pregnancy of five months, a tolerably practised ear will meet with but a small number of exceptions; M. Depaul found it 295 times in 307 women, who were beyond that epoch, and the sound was, therefore, absent only once for every 26.

Characters.—The phenomenon in question nearly resembles the sound of blowing caused by the compression of a large artery; but it exhibits a particular resonance, and occurs without any appreciable shock or jerk. It is synchronous with the radial pulse of the mother, partakes of its variations in rythm, and is subject to the same influencing causes. At one time it is very short, at another more prolonged, and, at the same time increased, so that it is difficult to isolate it from the blowing, which succeeds. It is seldom very distant from the ear, but varies greatly in intensisty; it is in one place highly developed, in another so feeble that it becomes only audible during the deepest silence and attention. It offers, likewise, numerous shades of sound and tone, either in the same or in different individuals; now, it is full and sonorous, again shrill and sibilant; sometimes it undergoes, successively, several variations, or each blowing commences in a low key and terminates in a higher one; occasionally its tone is somewhat metallic or musical. (Helm.)

Uterine blowing has no exclusive situation, for it shows itself on any point of the region of the uterus, which is accessable to the ear. Being rarely perceived at the fundus of the organ, and still more rarely at the loins, it most frequently attains its maximum at the inguinal regions, either on both sides, with different intensity, or on one only, and is thence

* See Note 3 O.

propagated towards the hypocondria or umbilicus. Being sometimes limited to an area of three or four square inches, it occasionally extends over the whole, or nearly the whole, surface of the uterus. In the first stage of gestation, the uterine sound is confined to the inferior regions occupied by the matrix, and is heard higher up as the organ ascends. It is perceived, at one time, on the same side with the sounds of the heart of the fœtus, at another on the opposite side. According to some, it is stationary, whatever place it occupies, according to others, it is susceptible of displacement. It is not in all cases permanent, for, on some days, it is difficult to find it, and, at another time, it has disappeared or changed its place; occasionally it ceases or reappears under the stethoscope. A slight pressure with the cylinder may be sufficient to remove it, and during strong uterine contractions, it ceases at the region of the fundus and body of the uterus, although it persists at the inguinal regions.

Uterine blowing appears generally towards the fourth month. The termination of the third month is the least advanced epoch, where M. Depaul has observed it; he has at that period found it but once in every eleven cases; the proportion increases afterwards rapidly; accordingly, in the epoch of from three months and a half to four, he has observed it thirteen times out of twenty-two, and, after the fifth month, 295 times out of 307. In thirty-five females M. Nægele has recognised it three times during the fourteenth week, and twenty times during the fifteenth. Dr. Kennedy affirms that he has heard it as early as the tenth week.

Laennec admits, according to Dr. Ollivry, that the sound ceases the instant the cord is divided; according to Nægele, it ceases after delivery, and M. Jacquemier observes also, that the sounds heard during labor have disappeared almost immediately after the expulsion of the fœtus. But, according to some authors, (Dubois, Depaul), we succeed sometimes in hearing the sound of blowing, even after the expulsion of the placenta, especially, adds M. Helm, when the uterus does not contract vigorously.

Differential diagnosis.—An inattentive examination might lead us to mistake the respiratory sound of the mother for uterine blowing, which is sometimes propagated as far as the hypogastriæ and the lumbar regions. But the slow rhythm of the vesicular murmur, its synchronism with the respiratory movements, and its intensity increasing progressively as the observer approaches the chest with the stethoscope, will

soon dissipate this error. The uterine sound may sometimes be confounded with the sounds of the heart of the mother, when they become audible beyond the umbilicus, and especially when blowing on the first third obscures or masks the second sound. As in the preceding case, we shall avoid mistakes by examining from below towards the precordial region, where the cardiac blowing has its maximum intensity.

Pulsations with blowing, accidentally developed in the abdominal aorta, or in the iliac arteries, and synchronizing with the pulse of the mother, are more easily confounded with uterine blowing; but they are recognised by the shock, which accompanies them, by their distance, as also by their disappearance, if by changing the posture of the patient we relieve the vessel from the pressure occasioning the abnormal sound, and especially by the absence of the double pulsations of the fœtus.

Physical cause.—The blowing sound of pregnancy has been very differently explained. M. de Kergaradec placed its seat in the placenta, or in that portion of the matrix where it is attached. Dr. Ollivry "having convinced himself by the introduction of the hand into the uterus, immediately after the birth of the child, that the point, where he had heard the pulsations, with blowing before delivery, corresponded exactly with that, where the placenta was inserted." Laennec concluded from this, that placental blowing, like that of the carotid arteries, must occur in an artery of a certain volume, and, according to him, the sound would proceed from that arterial branch, which serves principally for the nutrition of the placenta.

Dr. Hohl, expressing himself in a similar manner, says, that blowing depends on the passage of the blood into the substance of the placenta, and through the tissue of that organ. He rests his opinion on the following propositions. 1. We hear nothing analogons to blowing in women not pregnant. 2. An experienced ear perceives it in each pregnant woman. 3. It begins to show itself towards the fourth month, when the uterine vessels expand and elongate to form the uterine portion of the placenta. 4. It is most frequently heard on the right side of the uterus, and towards the fundus of the organ, at which region the placenta is generally attached. 5. It persists in whatever attitude the female may be, even when she rests on her knees and hands, so that pressure of the uterus upon the aorta or iliac arteries becomes impossible. 6. It is generally heard in a circumscribed space, cor-

responding to the volume of the placenta. 7. The sound diminishes in extent and clearness, as soon as the placenta becomes detached, and ceases entirely, when it is completely removed.

These propositions appear, at the first glance, conclusive; but the experience of other observers has proved, that they are not all equally correct, and some of them may also be asserted in favor of a different opinion.

Thus we hear, 1. the uterine sound independent of pregnancy, and especially in cases of fibrous tumors of the matrix. M. M. Stoltz, Bouillaud, Jacquemier, and Depaul, prove this by their observations.

The 2. and 3. arguments of M. Hohl are also applicable to the theory, which explains the sounds by uterine circulation; for in all pregnant women, the uterine vessels are greatly developed, and we may be sure of their dilatation the moment the matrix begins to rise above the pubis.

4. If blowing be more frequently heard at the place where the placenta is commonly attached, we have to observe, that the uterine vessels are at that point most developed. The fifth proposition includes, indeed, the influence of the iliac arteries, but it does not prove that blowing depends rather on placental than uterine circulation. 6. The sound is sometimes heard over the whole surface of the uterus, accessible to the stethoscope. 7. Finally, we know that the separation of the placenta is owing to a contraction of the matrix, which involves a diminution in the caliber of the uterine vessels, and a cessation of the sound; moreover, blowing may persist, even after delivery. We remark, at the same time, that M. Jacquemier has heard very distinct "sounds of blowing in three women, who gave birth to putrid children, and whose placenta contained in its vascular system coagulated, thickened and altered blood, which, however limited it was, prevented the circulation, and consequently suspended the passage of the fluid from the mother to the placenta."

These objections appear greatly to invalidate the opinion of those, who explain uterine blowing by placental circulation. Since 1831, M. P. Dubois advanced the hypothesis, that the sound was produced in the vessels of the matrix, and "as these vessels are chiefly developed at the point of the uterine walls, corresponding to the placenta, the blowing is naturally more distinct and loud, and in general even exclusively heard, at the place corresponding to the insertion of this vascular organ." This explanation received the assent

of a great number of observers, and has been maintained by MM. Nægele, Depaul, and Helm.

Another theory has been proposed by M. Bouillaud. He admits with Laennec, that the sound heard during gestation is a sound of blowing in the large artery; but he attributes it to the compression, which the uterus exercises on the hypogastric and external iliac arteries. M. Bouillaud replies to some of the objections made against this theory; 1. "That it is quite possible, that the arteries just mentioned are not uniformly compressed at the right and left side, and that these may consequently give a sound of blowing on one side, whilst the others do not. 2. That there are, besides, cases, where we hear distinctly the sound of blowing on both sides of the uterus at once."

M. Jacquemier advocates this opinion, and defends it by the following considerations: If we wish to elicit sounds of blowing in the superficial arteries, by momentary compressions, we are obliged to compress in one case firmly, in another, slightly; the same happens in gestation: the developed uterus is generally tilted from one side to the other; it is a moveable body, which may alter its relation to the iliac and hypogastric arteries almost indefinitely, and above all, subject these arteries incessantly to various degrees of pressure. Moreover, the reason why the sound appears so superficial, is to be sought for in its easy transmission through the uterus tenanted by the product of conception.

We remark, in opposition to those who, from prejudice, are averse to this explanation of M. Bouillaud, that the sound of blowing occurs rarely in the other cases of tumors of the hypogastrium, that these tumors, which are in general unequal and rugged, have nothing in common with the matrix, which, being regularly expanded by the liquid of the amnois, constitutes an even and globular body capable of exercising a surer and more uniform compression. Add to this, that the displacement of the fœtus in the uterine cavity, may likewise contribute to modify the sound of blowing, by altering the conditions of the pressure, upon the one or the other artery of the pelvis.

We do not mean, however, to say, that the theory of M. Bouillaud is not liable to any objections. If blowing be the effect of an arterial compression, why does it not increase in intensity, when we press with the stethoscope upon the uterus, and indirectly upon the vessels in the pelvis? Why does it even sometimes disappear, when the cylinder is close-

ly applied to the anterior region of the matrix? How comes it, that in some cases, where the auscultation performed on the abdomen, reveals no blowing, the sound was discernible by means of the metroscope of M. Nauche, at the neck of the uterus, which, being placed in the centre of the pelvis, is at a distance from the vascular trunks of this cavity? Finally, how shall we account by this theory, for the continuance of blowing in postures, where the matrix assuredly ceases to compress the large arteries? Might it perhaps depend in these cases on the compression of the epigastric arteries? We do not think this very probable.

After this criticism, it seems rather difficult to give without risk of error, an exclusive preference to the one or the other opinion. The above-mentioned circumstances may possibly contribute, simultaneously or alternately, to the production of the phenomenon; but the uterine circulation, and the compression of the arteries of the pelvis by the matrix, seem to arrogate the greater share of it.

Semeiological value.—Whatever may be the cause of uterine blowing, let us now enquire into its signification for the diagnosis of pregnancy. The following conclusions, borrowed from M. Paul Dubois, (*Dict. de Méd.* 2d edit. T. XIV. p. 360,) comprise some of the main points of this question:—

"Since uterine blowing is the natural consequence of the development of the vascular apparatus in the walls of the uterus, and since this development is generally owing to the presence of a product of conception within this cavity, we cannot but attach the greatest importance to this sound, for it renders the existence of the fœtus almost certain, when it concurs with other signs presumptive of pregnancy."

"As it is possible to hear uterine blowing at an epoch, where the double pulsations are not yet discernible, it has over these latter the advantage of informing us sooner of the existence of pregnancy."

"But as gestation is not the only cause of development of the uterus and of its vascular apparatus, and consequently of the coincidence of pulsations with blowing; moreover, as abdominal tumours, entirely foreign to the development of a product of conception, have several times given rise to the same phenomenon, it evidently follows, that the perception of pulsations, combined with blowing, cannot establish a certain diagnosis."

"Again, since uterine blowing does not always exist, or is

at least not always discernible, its absence does not necessarily imply the non-existence of pregnancy."

"It has been erroneously believed, that the presence or cessation of uterine blowing is an indication of the life or death of the fœtus. This sound persists though the fœtus is dead, because this circumstance does not change the vascular conditions, which occasion the combined sounds of pulsations and blowing."

"Since the pulsations accompanied by blowing are almost exclusively heard at that point of the uterine walls, where the vascular apparatus is most developed, and since that point is generally in contact with the placenta, the pulsation gives, in most cases, a correct idea of the place where that organ is attached."

We add to these considerations, the remark of Dr. Stoltz, that by means of the sound of blowing, we might possibly ascertain, whether there exist a double fœtus, "when two children are enclosed in the matrix, the sound will either be more loudly heard over a larger surface than in simple gestation, or it may be distinctly audible at two separate places;" but this sign is only of inconsiderable importance, because, on the one hand, blowing exists sometimes at two diametrically opposite places, when the gestation is simple (*P. Dubois*), and, on the other, a portion of the common placenta, or one of the two isolated placentæ, may, in the case of double pregnancy, be withdrawn from our investigation, so that we hear either a single sound of blowing, or one limited to a small surface.

But this is nothing at all; according to Dr. Hohl, judging from the perception of a species of whistling, which is then conjoined with the placental sound, it might also indicate, with considerable certainty, the presence of a calcareous deposit in the placenta. This assertion, based on the supposition, that blowing originates exclusively from placental circulation, is, however, very questionable; we cannot but say as much regarding the possibility of judging of the actual state of suffering in the fœtus, from the feebleness of the sound of blowing, and from its intermittence during the paroxysms of pain; blowing is too greatly modified to construct a sure diagnosis on the slight variations in intensity, or on the momentary disappearance of the phenomenon.

Finally, whatever theory we may adopt, we could not derive from the examinations of the sound of blowing, any precise indication, either in regard to the position of the

fœtus, or in regard to its presentations; "Although we have observed, (*Stoltz*), that the sound is generally heard on the side opposite to that, on which the back of the child is placed, too great confidence in this sign would expose us constantly to serious errors."

B. *Sounds accompanying the Displacement of the Fœtus.*

The sounds resulting from the movements of the embryo in the matrix, consist at one time in a brisk and dull shock, which may be single or double, and which is always accompanied by an impulse against the head of the observer; at another, in a slower and more prolonged friction-sound, which conveys to the ear a pretty distinct sensation of a body in the act of shifting.

These sounds, which, according to the age and strength of the fœtus, as also according to the quantity of liquid in the amnios, are of various degrees of intensity; and are, besides, very inconstant in their manifestation; for they appear, more or less frequently at irregular intervals. They become first audible towards the fourth month; the eye may at the same time often recognise, more or less, distinct jerking motions in various points of the abdomen. In other respects, these sounds present themselves to the observer, merely as the interpreters of the sensations evinced by the mother; nevertheless, they may, according to Nægele, become sometimes audible several weeks before the mother feels the movements of the embryo.

They could not be confounded with any other stethoscopic phenomenon furnished by the auscultation of the abdomen; and we perceive easily, that one of these sounds depends on the sudden shock, which the child imparts to the walls of the uterus, and that the other is connected with the displacement of the fœtus in the cavity of the matrix.

Hence we may easily form an idea of their semeiological value: their presence is a sure sign of the existence of a living fœtus, and this sign is of some value, when they appear before the mother becomes aware of its motions. In some cases, where the sound of blowing and the pulsations of the heart of the fœtus are perceived with difficulty, or where they are momentarily absent, their manifestation is of the utmost importance for the diagnosis of gestation. Their absence does not absolutely prove the non-existence of conception; but if, after being recognised, they should di-

minish and disappear, under circumstances capable of endangering the life of the fœtus, at the same time that the fœtal pulse becomes annihilated, they would indicate a morbid state of suffering in the embryo, and the termination of its existence.

C. *Double pulsations.*

Synonymes.—Pulsations of the fœtal heart; double sound of the heart of the fœtus; fœtal pulsation; double pulsation.

The double pulsations are heard in almost every pregnant woman; their absence is the more rare the nearer the female is to the period of delivery. Indeed, M. Jacquemier has, out of 179 cases, but once noticed their absence, during the three last months of gestation.

Characters.—The fœtal sound is formed of double pulsations, and of a precipitate *tic-tac*, bearing a great resemblance to that perceived on examining the heart of a new born infant. It is composed of two very distinct sounds, which are separated by a very short interval.

The first is louder, the second feebler, and they are repeated in couples, always observing the same rhythm. According to M. Nægele, the ear perceives sometimes but one sound, which may be either the first or the second. Occasionally, we may also hear in the same individual, two double pulsations, somewhat dissimilar in rhythm.

The number of these pulsations varies from 120 to 150 per minute, and seldom exceeds these limits. Dr. Nægele has deduced from his observations on 600 women, the extreme numbers of 90 and 180, the mean average being 135, and the numbers 130 and 134, as those of most common occurrence.

M. Jacquemeir obtained 160 and 108 as extreme numbers, and 183 as the average, from 51 women in the ninth month of pregnancy. This frequency may, besides, vary with the period of gestation; and it is generally admitted that it diminishes with the maturer age of the fœtus.

Other observers are of opinion, that in every individual it remains nearly the same during the whole period of gestation (Depaul, Jacquemier); in some cases we have noticed the pulsation at different epochs, amounting sometimes to 150 five weeks previous to the delivery, and sinking to 138 seven days before that event. These pulsations undergo, be-

sides, momentary variations; they are, for example, observed to accelerate, subsequent to the motions of the fœtus, and to resume afterwards their habitual rhythm.

The double pulsations increase generally in intensity, from the time of their manifestation, and become more and more distinct with the growth of the fœtus. Their intensity varies likewise with the individuals, and we have to enumerate, amongst the causes, which may enfeeble or annihilate them, a great abundance of the waters of the amnios, considerable thickness of the abdominal walls, the excessive volubility of the matrix, and certain postures of the fœtus. They diminish also or disappear during powerful contractions of the uterus, being then obscured by the muscular sound. We remark, in addition, that in the same individual they do not appear during each examination with the same distinctness and intensity; and that they may, moreover, in cases of disease, undergo modifications, and be accompanied by a sound of blowing.*

In their state of feebleness, we may easily, with some precaution, discover them; we must select on the uterus a solid point, and depress the abdominal walls, with the view of establishing a continuous conductor from the origin of the sound to the ear. We have to observe, that the moment they first strike the ear, they appear often confused, but the sensation becomes gradually more distinct.

The sounds of the fœtal heart occupy a variable seat, and their maximum may, by turns, traverse every point of the abdomen. M. Jacquemier, on examining 196 women, found this seat to be 62 times on the left side, 54 times on the umbilical region, 49 times on the whole anterior region, and 31 times on the right side. When we hear them on both sides they are generally more distinct on the one than on the other, and pretty frequently on the side opposite to that, in which uterine blowing is most conspicuous.

The extent of surface, over which we perceive the fœtal pulsations, varies from some inches to a large area, comprising all the parts accessible to the ear. The sounds are also heard, when the fœtus is voluminous, and when its heart contracts with energy, or when the waters of the amnios exist in small quantity.

In the same individual the sound is neither stationary nor permanent, nor constant in character and intensity. It di-

* See note 3 P.

minishes or increases, and ceases sometimes altogether for several hours or days; on a re-examination it appears afterwards, at a point different from that, at which it was previously heard. It often changes its place or intensity during the same exploration.

It does not appear at a fixed period; but it begins generally to be heard between the fifth and sixth month, and sometimes during the fifth. M. Dubois says, he has perceived it distinctly at four months and a half; and Dr. Nægele, during the eighteenth week. M. Depaul could not recognise it in 11 women during the third month; he has twice noticed it in 22 women at three months and a half, and 12 times at about four months: it was 14 times absent, in consequence of the death of the embryo. He heard it 25 times in 36 women at the close of the fourth month; 281 times in 307 women, examined between the fifth month and delivery; and out of 26 cases, where it was absent, 21 revealed the death of the fœtus.

The fœtal sound may undergo various modifications, which we have already pointed out, but it ceases definitively only with the life of the fœtus. It remains, besides, during its whole duration, in most cases, independent of the maternal circulation, and is not influenced by the derangements of this latter. M. Depaul observed the double pulsations, with their ordinary rhythm, during the paroxysms of eclampsy. In several acute diseases, he has even witnessed the maternal pulse rise to 140, and that of the fœtus remain between 130 and 135, as it was previous to the attack.

Differential diagnosis.—The sounds of the fœtal heart are commonly characterised by their tone, and, above all, by their rapidity: they could not be mistaken in the immense majority of cases. From the influence of different causes, the pulse of the mother may, however, become quickened, and rise to 120 or 140 per min., whilst, at the same time, the pulse of the fœtus undergoes no change; moreover, the sounds of the maternal heart propagate sometimes beyond the umbilicus. If these two circumstances (acceleration and extensive transmission of the pulsations) occur together, errors may be committed, which are, however, easily corrected, when, by a more attentive comparison of the maternal and fœtal pulsations, we convince ourselves that they are not synchronous. This synchronism may possibly exist, but then, if the double pulsations belong to the mother, we observe their intensity to increase in proportion as we examine

farther up towards the precordial region; if they depend on the fœtus, their maximum will occupy one of the points of the abdomen corresponding to the uterus.

We might also elucidate the question on modifying the maternal circulation, for example, by a moral emotion, which would not extend its influence over the circulation of the fœtus. The pulsations of the aorta could not be confounded with the sounds of the fœtal heart, because they are simple, and accompanied by an impulse, whereas, on the other hand, the pulsations of a healthy fœtus are double and without impulse.

Physical cause.—The cause of double pulsations is not so uncertain as that of uterine blowing, for they are undoubtedly constituted by the sounds of the fœtal heart. In truth, the fœtal heart contracts before these sounds are heard, but several conditions are necessary for its perception; they require to be sufficiently loud: the fœtus must be in contact with the uterine walls, and the uterus with the wall of the abdomen, in order to transmit them to the ear. These conditions combine only after the fifth month, when the fœtus is already greatly developed, and when the uterus rises behind the pubis; this explains, why the sound does not appear before this period, and why it increases with the strength and growth of the fœtus.

It is also evident, from the preceding remarks, that the sound is not equally well perceived in all positions of the fœtus. M. Jacquemier and Depaul, in order to determine that part of the body, which is the best conductor of the sounds, examined a number of new born infants, and came to the conclusion, that the cardiac pulse is less distinctly heard on the back of the chest, than on the front, and especially on the precordial region. But this is different with the fœtus contained in the uterine cavity. As it is coiled up, and inclined forward, the anterior portion of its body with difficulty adapts itself to the walls of the matrix, and the heart is necessarily at a distance from the ear of the observer. The posterior portion of the trunk is, on the contrary, in more immediate contact, and the cardiac pulsations are, besides, more easily transmitted; the density of the lung, which has not yet performed its functions, its inferior thickness, and the absence of the vesicular murmur, are in favor of the transmission. Hence it follows, that the proximity of the back presents a better condition for the perception of the sounds, which are less distinct, if the fœtus present anteriorly. For

the same reason we can understand, that a very large quantity of the waters of the amnios is unfavorable to the transmission of the double pulsations.

Semeiological value.—What is the value of the phenomenon just examined? How far may it serve to determine the existence of pregnancy, whether simple or double, whether the fœtus is alive, healthy, or diseased, as also its different positions and presentations?

According to the preceding remarks, uterine blowing furnishes no positive information for the solution of these questions; it renders the existence of pregnancy, the point of attachment of the placenta, and the number of the fœtuses and placentæ merely probable. The case is different with the double pulsations, which constitute a sign of the utmost importance for the diagnosis of gestation, a sign, which, from the fifth month, acquires, every day, greater value, as it occurs the more surely, the more we approach the hour of delivery, and, as it almost never fails, during the three last months.

We know that, previous to the third month, it offers no assistance to our diagnosis; but, calculating from the time it usually makes its appearance, it becomes a valuable index, more, however, by its presence than by its absence. Indeed, its absence, during that period, does not prove the non-existence of pregnancy, but, with the progress of time, it confirms, more and more, the presumption of the non-existence of a fœtus; yet, even to the very last, it cannot prove, beyond all doubt, that pregnancy does not exist. On the other hand, its presence is a pathognomonic sign of the existence of a fœtus, because the fœtal heart can alone produce double pulsations.

Does the perception of double pulsations on one side only imply, that there is but one fœtus? This diagnosis is probable, but not certain, because women have been delivered of two children, where the pulsations were perceived only on one side, and over an inconsiderable surface. This fact, whatever its cause may be, has been recognised in cases, where the two fœtuses were born alive; it would be more easily explained if one of the two died during gestation. On the other hand, if we hear two double pulsations, one on the right side, the other on the left, with diminished intensity of the sound during the interval of separation, the existence of two fœtuses is probable; but it is not yet certain, because, even in cases of simple pregnancy, the pulsations

may be perceived over the whole globe of the uterus, and sometimes even on the right and left side, and yet be feeble or absent at the intermediate points.

The probability of a double conception increases, however, if the pulsations be much developed on both sides; if they vanish gradually towards the region, which separates them, in proportion as we recede from each of them; finally, if a transverse line being drawn to the central part of the abdomen, one of the double sounds have its maximum above and the other below. The doubts would become certainty if, by counting distinctly the pulsations on both sides, we obtain two very different numbers per minute; for each fœtus has its particular circulation within the common matrix. The diagnosis would be equally positive, if, at any point, we heard a mixture of pulsations, conveying to the ear the sensation of very precipitate sounds, which happens when the two cardiac pulses are nearly equal in frequency; or also, if we perceived mixed pulsations, which become for a moment synchronous, but lose immediately this synchronism, by gaining on each other, which takes place, when the frequency of the one is different from that of the other.

We remark, moreover, that sometimes a double conception, which, previously to the rupture of the amnois, had not been revealed by any stethoscopic phenomenon, may be recognised after the flow of the amniotic liquid, because the double pulsations are now become so distinct in two regions so distant, that they are almost sure to result from the impulse of two hearts.

Can auscultation, which renders the diagnosis of normal gestation so precise, throw any light upon that of extra-uterine conceptions? If, at the inferior region of the abdominal cavity, a tumor be observed to increase gradually, the formation of which coincides with the suppression of the monthly discharge in a woman, who is still young, and has had regular menstruation, &c.; if, on the other hand, we recognise, by the touch, that the matrix is small and empty, the existence of an extra-uterine conception is probable; we remain, nevertheless, in doubt in regard to the true character of this tumor, as long as auscultation reveals no particular sound. But as soon as, under these circumstances, we perceive a double sound entirely independent of the circulation of the mother, the existence of extra uterine gestation becomes indubitable.

Let us now suppose, that the cavity of the matrix incloses a living fœtus. May we succeed in determining the condition of the child relative to the uterus, by the auscultation of the double pulsations, and, consequently, discover its positions and presentations? The opinions are divided on that point. The greater number of observers, and amongst them M. M. Moreau and P. Dubois, do not consider this determination possible.

M. Jacquemier is likewise inclined to think that the examination of the sounds of the heart, *during the period of gestation*, is of little use in ascertaining the different position of the fœtus; "but," he adds, "at the commencement of labor, when the waters are discharged, when the uterus is closely applied to the body it contains, auscultation, assisted by the touch, gives valuable information, which often leads us to infer with accuracy the position of the fœtus, and its co-relation with the different points of the cavity of the pelvis."

Dr. Nægele attributes great value to the stethoscope, and, according to him, we may, by that instrument, distinguish a transverse presentation from a presentation of the one or the other extremity. Moreover, when the touch enables us to recognise the extremity presented, we may then ascertain its position by the ear, at a period, when the finger is inapplicable, and decide whether it be a first or second position according as the pulsations are heard on the left or right side.

MM. Stoltz and Depaul have enlarged on the advantages of auscultation, for the diagnosis of the fœtal positions; the latter, in particular, dwells upon the importance and precision of the stethoscopic data; his thesis is a complete exposition of the notions, which obstetrical semeiology derives from the examination of the double pulsations of the fœtus. We here transcribe the following principal conclusions, the value of which will be better determined by the results of farther observations.

M. Depaul assumes as a principle, that there exists a point of the uterus, where the double sounds of the heart obtain their maximum, and that a practiced ear may determine it precisely, even when they propagate over the whole body of the uterus. He reminds us also, that this maximum corresponds with the left scapular region of the fœtus, and makes the observation, that this point is nearer to the cephalic than to the pelvic extremity.

From these premises, he draws the following principal conclusion, relatively to the *presentations* of the fœtus: When the head is in the pelvis, the point corresponding to the maximum of the sounds of the heart is situated lower down, and these sounds diminish from below upwards. When on the contrary, the breech is the presenting part, the maximum is found higher up, and the sounds decrease from above, downwards.

An imaginary line, dividing horizontally the uterus into two equal halves, enables us to register amongst the presentations of the pelvic extremity, all cases, where the pulsations of the heart are recognized with their maximum intensity above that line; and to classify under the presentation of the head, all those much more numerous cases, where the greatest energy in the pulsations is perceived below.

When the fœtus is placed transversely above the superior orifice of the pelvis, its two extremities being inclined towards one another, and turned towards the fundus of the uterus, the double pulsation exists below the line, but above it, the sounds are not even feebly heard, and they decrease, as we examine them, in the direction of the horizontal line.

Moreover, the maximum intensity is nearer, to the right iliac fossæ, when the occiput is turned to the right, and the reverse, if it be turned to the left.

This determination of the seat of the sounds to the right or left, serves also to indicate, with more precision, the presentations of the cephalic or pelvic extremity; they are heard over the left half of the uterus, when the dorsal region of the fœtus is turned towards the left side of the pelvis, and *vice versa.* A vertical line drawn through the centre of the horizontal line, indicated above, forms for both cases a pretty exact limit of demarcation; and, by means of these two lines, all the accessible points of the uterus are thus divided into four portions, viz: two superior and two inferior.

When the most energetic contraction of the heart corresponds to the left inferior quarter, there exists a presentation of the head, and the back will be turned towards that side. When it is perceived at the right inferior quarter, the head still occupies the superior orifice, but the back corresponds to the right half of the pelvis. When it is heard at the left superior quarter, we are informed that the breech is in the lowest part, and that the back is to the left; finally, the pelvic extremity of the fœtus may present at the brim of the pelvis, but the back is turned towards the right side, when

we recognise the presence of the heart at the corresponding superior quarter.

The preceding details entitle us to presume, that in the generality of cases, we may arrive at a greater precision; that we may, for example, ascertain, whether the back is inclined more forward than backward, and consequently distinguish a first position from a fifth; a second from a fourth; and, in regard to the breech, avoid the confusion of a sacro-cotyloid with a posterior sacro-iliac position.* In the one case, the heart is nearer to the linea alba, and farther off in the other. We should not forget, that in proportion as we examine nearer to the vertebral column, the exploration becomes more difficult, from the form of the uterus and the presence of the intestines; and it requires some practice to annihilate the influence of these obstacles by sufficient pressure of the stethoscope.

We now pass on to the last question, the solution of which is of great importance in obstetric practice: Can auscultation be of use in determining the healthy or unhealthy condition of the fœtus? If double pulsations prove the existence of a fœtus, their energy, distinctness, and regularity, inform us of its healthy condition. On the other hand, the change of one of the sounds, for example, the transformation of the first into blowing, indicates a morbid condition of the fœtus. Their dimunition, retardation, inequality, and intermittence, after they had previously been well developed, of normal frequency, and regular in their rhythms, would certainly announce a state of suffering of the infant: and if these derangements become more serious, if the feebleness increase, if the intermittence be prolonged, and form regular pauses, and if, afterwards, the sounds cease altogether, we conclude by these signs, that it has ceased to live.

The disappearance of the fœtal pulse, between two succeeding examinations, is of minor importance, as we know, that a mere change in the position of the fœtus may cause the cessation of the sound. We have more reason to fear if the pulse continue to be absent for several days, and if this occur after accidents capable of seriously affecting the fœtus, such as a fall, &c. On the contrary, the continuation of the sound, after the action of causes, that might endanger the life of the embryo, is a sure sign, that it is still alive.

We may easily form an estimate of the practical conse-

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* Note 3 Q.

quences resulting from the preceding remarks. Auscultation, by establishing the existence of pregnancy; when the signs derived from other methods leave us in doubt, prevents the application of therapeutic means, which may be useful in an intercurrent affection, but the untimely administration of which might prove fatal. Again, in the case, where a woman conceals her pregnancy, the recognition of an infallible sign, which it is impossible to conceal, when the stethoscope is brought to our aid, will make us reject the dangerous application of remedies prescribed for a fictitious disease, which might have produced abortion.

Auscultation, by announcing the existence of two fœtuses, suggests to the practitioner his method of procedure, either during delivery or after the birth of one of the two infants.

By revealing double pulsations in an extra-uterine tumor, it prevents the commission of sad mistakes, when the surgeon, fancying that he has to treat a simple cyst, is tempted to plunge a trocar into the tumor.

By contributing to the diagnosis of the presentations and position of the fœtus, it informs us, when we require the active intervention of the obstetric practitioner.

If the double sounds continue to preserve their energy and regularity, the physician may form a favorable prognosis, and consider himself secure; whereas, on the contrary, their feebleness, retardation, and irregularity, are the harbingers of imminent danger, and demand our intervention. If these derangements take place during pregnancy, we should consider that they frequently depend on congestions, so that their appearance, along with the symptoms of plethora in the mother, suggest to us the necessity of drawing blood, whereby the fœtal circulation may recover its regularity. If this derangement of the double pulsations happen during prolonged labor, it announces a dangerous position of the fœtus, and an amount of compression, which may cause death; hence it becomes necessary to terminate the delivery as soon as possible, either by turning, or with the forceps, according to circumstances; the physician may thus save a child, which, by delaying too long, would have perished.

Auscultation is no less useful, if we have to decide, whether the fœtus be alive or dead, with the view of ascertaining, whether we shall bring the instrument to bear on the mother or on the child, in case the delivery becomes impracticable without a surgical operation. The practitioner, enlightened

by the information derived from a knowledge of stethoscopy, will not run the risk of dismembering or destroying, with the céphalotribe or crochet, a living fœtus, nor will he perform the Cesarian operation on a woman bearing a dead child unless the extreme narrowness of the natural passage forbid embryotomy.

Auscultation furnishes, likewise, the means of determining the proper time for the induction of premature delivery. Finally, it saves the mother from the chances of an operation, which places her health or life in jeopardy, having for its object the extraction of an ill-conditioned child from the uterus, which is, to be sure, still alive, but doomed to die immediately after its birth.*

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* See Note 3 R.

RECAPITULATION.

CHAPTER I.

AUSCULTATION OF THE RESPIRATORY APPARATUS.

The auscultation of the respiratory apparatus is performed on the *thorax* and on the *laryngo-tracheal* tube.

The auscultation of the chest has, for its object, the examination of three classes of phenomena, furnished by the respiratory *murmur*, the *voice* and the *cough*.

ART. I. RESPIRATORY MURMUR.

§ I. *Normal Respiration.*

If, in the physiological state, we apply the ear to the chest of a healthy individual, we hear, during the act of breathing, a slight murmur, analogous to that produced in quiet sleep, or in uttering a deep sigh: this is, *the natural respiratory sound*, or *vesicular murmur.* It is of a soft and gentle character, and composed of two distinct sounds, that of *inspiration*, which is more intense and prolonged, and that of *expiration.*

The vesicular murmur is louder in those points which correspond to a greater depth of the lung, and is a little harsher towards the root of the bronchiæ (*normal bronchial respiration*). It is equal at the corresponding points of both sides, and in some individuals more intense at the summit of the right lung. The vesicular murmur is louder, when the respiration is full and rapid, more intense in children, (*peurile respiration*), and, on the other hand, more feeble in the majority of old people. It is in general the more intense, the greater the capacity of the chest, and the thinner its walls.

§ II. *Alterations of the Respiratory Murmur.*

We may arrange these into four classes.

1. Alterations in *intensity.*

2. In *rhythm.*
3. In *character.*
4. Alterations caused by *abnormal sounds.*

1. *Alterations in Intensity.*

Respiration, considered in this point of view, may be *loud*, *feeble*, or *absent.*

A. *Loud or Puerile Respiration.*—Consists in a vesicular murmur more intense than in the natural state, but preserving the soft and gentle character of normal respiration. It indicates less a lesion of the pulmonary organs, where it is heard, than a disease of a more or less distant portion, so that the healthy parts may be said to *compensate* for the inaction of those affected.

B. *Feeble Respiration.*—It is characterised by a diminution in the normal tensity of the vesicular murmur, which at one time preserves its natural character of softness, and becomes somewhat harsher at another. This depends either on the sound being less completely transmittted to the ear, or on its being produced with less intensity.

In the former case it may be owing to *pleuritic effusions*, to *dense pseudo-membranes* deposited on the pleura, or to *tumors*, which separate the lung from the walls of the thorax. In the latter case, it arises from *pleurodynia*, from *stricture of the larynx*, from *partial obstruction of one or several bronchial branches*, caused by an accumulation of mucous, or by the presence of a *foreign body;* finally, it arises from compression of their walls by tumors. It is likewise met with in pulmonary emphysema, and in the first stage of phthisis.

Of all the dieases, which we have just enumerated, and which are often revealed by feeble respiration, the physician ought to fix his attention almost exclusively on tubercles, pulmonary emphysema, and pleurisy with effusion, because they are by far the most frequent, (*bronchitis*, which is equally common, has its special râles). If feebleness of the vesicular murmur coincides with exaggerated sonority of the thorax, it is a case of emphysema, if with dullness on percussion, tubercles or pleuritic effusion are present. If feeble respiration, accompanied with dulness on percussion, be limited to the summit of the lung, the existence of tubercles is probable; if it be circumscribed at the base, *pleuritic effusion* has in all likelihood taken place; if it exist on the summit of both lungs, the presence of tubercles on both

sides is almost certain; if it occur at the base of both lungs, there will be *double pleurisy*, or *double hydrothorax*.

C. *Absent Respiration.*—Respiration is said to be absent, when the ear, applied to the chest, hears absolutely nothing; the vesicular murmur is then wanting, and no sound replaces it; there is complete silence.

Absent respiration is connected with the same material conditions as feeble respiration, and indicates consequently the same diseases, with this difference, that the anatomical lesions are more developed. But the complete silence of the respiratory murmur being almost an *exception* in *emphysema* and *tubercles*, the diseases of the larynx being accompanied by particular phenomena, the obliteration of the bronchiæ, and their obstruction by foreign bodies, being, like pneumothorax, *comparatively rarer* affections than pleuritic effusions, it follows that the absence of the respiration is a sign of *very great value*: if it be recognized on one side only, at the central regions, or at the two inferior thirds of the chest, along with dulness on percussion, it indicates almost infallibly *pleurisy with effusion*, and if on both sides, an accumulation of serum in both cavities of the pleura, with or without inflammation. In cases of far less common occurrence, there prevails *complete silence* over the whole extent of one side of the thorax; if there exist at the same time dulness on percussion, the presence of alarge liquid effusion is certain; if tympanitic sonority, the effusion is gaseous.

2. *Alterations in Rhythm.*

The respiration, altered in its rhythm, may be *rare* (from twelve to seven respirations per minute), as in several diseases of the *cerebro-spinal apparatus*, or *frequent*, (from thirty to eighty), as in a great many affections of the thorax or abdomen. It is sometimes *abrupt* in asthma, pleurodynia, commencing phthisis, chronic pleurisy terminating by adhesions, &c.

At one time it is *long*, at another *short*, or, finally, an alteration takes place especially during the second act of respiration: the expiration becomes *prolonged*, and the respiratory sound is at the same time almost always harsher.

The last of these various alterations is alone of any importance to diagnosis. We may say, that prolonged expiration is the sign of only two diseases, viz: of *pulmonary emphysema*, or of *tubercles* in the period of crudity. In some cases, it is the first, or only stethoscopic sign of phthisis.

3. *Alterations in Character.*

A. *Harsh Respiration.*—It exhibits various degrees of force, hardness, and dryness, and these alterations may occur during both acts, or more especially during one.

We observe it in *emphysema* of the lung, in *commencing phthisis*, and finally, in all cases, which are characterized by pulmonary induration, (melanosis, cancer, &c.) Of all these diseases, *emphysema* and *phthisis* give rise most frequently to harshness of the respiratory murmur. If this harshness be accompanied by dryness, and if these alterations coincide with a vaulted form, and exaggerated sonority of the thorax, they indicate *pulmonary emphysema*. If harsh respiration be associated with the sound of prolonged expiration, and if it be limited to the summit of the chest, along with resonance of the voice, and dulness on percussion, we ought to establish the diagnosis of crude tubercles.

B. *Bronchial or Tubular respiration*, (tubular or bronchial blowing, bronchial respiration).—Bronchial respiration, which is at once remarkable for its increased intensity, and for its higher tone, is very easily imitated, by blowing into the hollow of the hand, or into a paper cyiinder, or through the stethoscope; the sound thus produced resembles tubular blowing in proportion to the force and rapidity of blowing.

Bronchial respiration, when but slightly marked, differs little from *harsh* respiration, of which it is but a higher degree. If well developed, it has a particular *tabular* tone, which serves to distinguish it from *cavernous respiration*, which is generally of a peculiar *hollow* character.

Bronchial respiration may shew itself in certain *dilatations* of the bronchiæ, but it indicates generally a *pulmonary induration;* now, of all these alterations, which may increase the density of the lung, *pneumonia* and *tubercles* are incomparably the most common. In pneumonia all the conditions of bronchial blowing are found combined, whereas several are absent in tubercles, so that tubular respiration is an almost pathognomonic sign of *hepatization of the lung*: it exists only as an exception in pleurisy, and it indicates in this case almost always pleurisy complicated with pneumonia or tubercles.

C. *Cavernous respiration* (cavernous blowing).—Resembles the sound caused by blowing into a hollow space: we imitate it by breathing forcibly, keeping the mouth wide open, into the cavity formed by both hands. Its favorite seat is the summit of the chest.

It indicates the pouch-like dilatations of a pretty voluminous bronchia, or the existence of a *cavern*, properly so called. But contrasting the rare occurrence of *pouch-like bronchial dilatations*, and of pulmonary excavations, following abscess, gangrene, apoplexy of the lung, &c. with the frequent occurrence of tubercles, we may conclude, that nine times out of ten, cavernous respiration indicates a cavern, resulting from the breaking up of tubercles.

D. *Amphoric respiration.*—It is a resonant sound, of a metallic tone, which we may easily imitate by blowing into a jug three parts empty, or through the narrow neck of a glass bottle with resonant walls. It coincides frequently with *metallic tinkling.* Well characterized amphoric respiration indicates almost infallibly *pneumothorax* with *pulmonary fistula*, and pneumo-hydrothorax if it be accompanied by metallic tinkling. If imperfectly characterized, it may indicate the existence of those diseases, but it may also be the sign of a large, and almost always tuberculous cavern.

4. *Alterations caused by Abnormal Sounds.*

The abnormal sounds are of two classes, viz. râles, and friction sound (*frottement.*)

1*st Genus. Friction Sound.*

Pleuritic friction.—The two folds of the pleura, which, during the movements of the lung, glide in the normal state *silently* over one another, cause a friction sound, when certain pathological conditions coincide. Pleuritic friction, somewhat analogous to the rustling of dry parchment, is commonly abrupt, and as it were composed of several successive sounds of crackling. It exhibits varieties of harshness and intensity, which we divide into gentle friction sound or rustling, and harsh friction sound or rasping; when it is very loud, it is perceptible on applying the hand to the thorax, and the patient may sometimes become sensible of it himself.

In order that the gliding of the lung over the internal surface of the thoracic walls may manifest a sound during the movements of ascent and descent of the ribs, it is necessary, that the folds of the pleura, or at least one of them, present on their surface asperities, which depends almost always on the presence of pseudo-membranes.

The sound of pleuritic friction is met with in *pleurisy*, in some cases of tubercles on the pleura, without adhesions, in some other organic alterations of this membrane, and very rarely in certain varieties of pulmonary emphysema. But this phenomenon indicates, most frequently, pleurisy in the progress of cure. If it be heard *exclusively* at the summit of chest, it may lead us to suspect tubercular pleurisy.

2d *Genus. Râles.*

The râles are abnormal sounds, which, forming in the air passages, mingle with the respiratory murmur, and obscure or supplant it completely. We divide them into two groups, the one species is called dry, because it consists of variable *sounds;* and the other moist, because it is characterised by bubbles.

1. *Dry râles.*—We comprehend, under this name, the principal varieties of *sonorous râle*, viz. the sibilant and snoring rale.

The sonorous rale, which generally supplants both acts of respiration, is characterised by its musical tone; at one time, it consists in a more or less acute sound of whistling (sibilant râle); at another it resembles the snoring of a person asleep, or rather the sound, which a bass cord yields under the touch of the finger (*snoring râle*). Both these varieties, which are often combined, alternate occasionally, and supplant one another.

The sonorous rale may be heard in a great many diseases, such as acute and chronic inflammation of the bronchiæ, tumours situated on the course of the tubes, and pulmonary emphysema, which are indeed different morbid conditions or states, but have all one element in common, viz. the momentary or permanent stricture of one or other portion of the air passages. On account of the frequency of bronchial catarrh, and of the comparatively rare occurrence of other morbid conditions, where snoring or whistling may manifest themselves, sonorous r le indicates, almost to a certainty, an inflammatory state of the bronchiæ.

2. *Moist Râles.*

They comprise the crepitating, sub-crepitating, and cavernous rale.

A. *crepitating râle.*—The crepitating or vesicular rhonchus

conveys to the ear the sensation of a fine and dry crepitation, analogous to the sound produced by the decrepitation of salt under a gentle heat in a basin, or to that yielded by pressing a portion of the lung filled with air between the fingers. Its bubbles, exclusively perceived in inspiration, are very small, very numerous, of equal size, and somewhat dry. The favorite seat is the posterior and inferior portion of the chest, on one side only.

It is distinguished from sub-crepitating and cavernous rale, by the smallness of its bubbles, and their rapid formation, by its exclusive coincidence with inspiration, and by its seat. It is produced by the passage of the air through liquids contained in the pulmonary cells.

Crepitating râle shows itself in *pneumonia*, in certain forms of pulmonary congestion, in œdema, and in apoplexy of the lung. On account of the extreme frequency of inflammation of the lung, when contrasted with the comparatively rare occurrence of œdema and apoplexy, the crepitating rhonchus, especially when its characters are well marked, is the almost pathognomonic sign of pneumonia, at the period of engorgement.

B. Sub-crepitating râle, (mucous or moist bronchial râle). The subcrepitating râle has been correctly compared to the sound produced by blowing with a reed into soapy water. The variable volume of its bubbles distinguishes it into sub-crepitating râle with small, moderately large, and large bubbles: the number and character of the bubbles are also variable. This râle accompanies inspiration and expiration, and its favorite seat is the inferior and posterior portion of the chest on both sides.

It is distinguished from crepitating râle by the concurrence of the characters indicated above, and from cavernous râle, by its favorite seat, and by the absence of cavernous respiration. It is produced by the passage of the air through liquids (blood, mucous, or pus), contained in the bronchiæ, or in small caverns.

The sub-crepitating râle may be perceived in various diseases, such as the second stage of inflammation of the bronchial mucous membrane, different species of catarrh, bronchoragia, dilatation of the bronchiæ with super-secretion, certain forms of congestion, pulmonary apoplexy, and phthisis in the stage of breaking up the tubercles. But of all these affections, the two most common are unquestionably bronchitis and tubercles at the commencement of softening;

the manifestation of sub-crepitating râle should, therefore, in a special manner, suggest to us the existence of those two diseases, and the knowledge of the favorite seat of the rhonchus should guide us in the diagnosis. If the bubbles, from being very numerous at the base, diminish in proportion as the ear advances towards the summit of the chest, the existence of bronchitis is almost certain: if, on the other hand, from being absent or less numerous at the base of the thorax, they become more and more evident and abundant in proportion as we carry the auscultation higher up, we establish the diagnosis of tubercles in the stage of softening.

C. Cavernous râle (gurgling).—This rhonchus is characterised by the bubbles being less numerous, large, and unequal in size, and mingled with cavernous respiration; it is this mixture, which forms its decisive character. It it is perceived in inspiration and in expiration, and generally circumscribed at the summit of one or both lungs. This rhonchus, although occupying the superior portion of the chest, exhibits sometimes smaller bubbles of a sharper tone, without admixture of cavernous respiration, this constitutes the cavernous râle.

The cavernous rhonchus indicates the existence of a cavern, which contains liquid set in motion by the penetration of the air. Sometimes again it indicates a pouch-like bronchial dilatation. If cavernous râle coincide with cavernous voice, and if it occupy the summit of the lung, it is the almost certain sign of a tuberculous excavation.

Appendix.

There are, besides, other abnormal sounds, not so distinctly characterised, and more rarely perceived, the value of which has been less precisely determined; these are, at one time sounds of crackling or plaintive cries, at another sounds somewhat analogous to the dull clapping of a valve; sometimes we fancy, that we hear a sound of pulmonary crumpling. These phenomena seem to refer to the existence of tuberculous excavations, with the exception of the crumpling and crackling sound, which is only perceived at the commencement of pulmonary phthisis.

ART. II. AUSCULTATION OF THE VOICE.

If we examine, by means of the stethoscope, the larynx

of an individual in the act of speaking, we perceive a pealing resonance, which traverses the instrument, and strikes the ear forcibly; this resonance, which progressively diminishes in the trachea and large bronchiæ, becomes but a confused buzzing in the chest. The natural resonance of the voice, which represents exactly all the varieties of the voice itself, is the more intense the louder and more sonorous the latter, the nearer we examine to the large bronchial tubes, the greater the capacity of the chest, and the thinner its walls.

It is equal at the corresponding points of both sides, and somewhat better marked towards the summit of the right lung, on account of the greater volume of the right bronchiæ.

In the pathological state, the vocal resonance is sometimes only exaggerated, sometimes it undergoes modifications in character, and the voice becomes bronchial, bleating, cavernous or amphoric.

A. *Exaggerated resonance of the voice, or slight bronchophony*, is characterised by a somewhat louder resonance of the voice than in the normal state, and is but one degree inferior to bronchial voice (true bronchophony.) It is connected, in general, with similar alterations, which are, however, less distinctly marked.

B. *Bronchial voice* is much louder than normal resonance: it is remarkable for its intensity, its extent, its localization, and its permanence. It may be recognised in dilatation of the bronchiæ, in pleurisy, and above all, in induration of the lung. But, on account of the rare occurrence of dilatation of the bronchiæ, bronchophony indicates almost always pulmonary induration; now, of all the alterations, where the density of the lung is increased, pneumonia and tubercles are incomparably the most common. The conditions of bronchial voice being better fulfilled in pneumonia than in tubercles, it is more distinctly marked in the former disease than in the latter; it exists only as an exception in pleurisy, and indicates, that a pleuritic effusion is complicated with pneumonic or tuberculous induration.

C. *Bleating voice* (*ægophony*), is a particular resonance of the voice, of an acute, tremulous, and abrupt tone. We might almost fancy, that the patient speaks with a counter between his teeth, (*polichinello voice*). It is generally heard on one side only, at the inferior half of the sub-spinous fossæ, where it is also mostly developed; it may change its seat, according to the posture of the patient, and commences

almost always with feebleness or silence of the respiratory murmur. True ægophony indicates a liquid effusion into the cavity of the pleura. If it be perceived on one side only, with coincidence of fever, it is a case of *pleurisy;* if on both sides, without fever, and with general dropsy, there is hydrothorax. If it appear in the course of inflammation of the pulmonary parenchyma, and if it shift its seat in conseqeunce of a change in the posture of the patient, it indicates *pleuropneumonia.*

D. *Cavernous voice* (*pectoriloquy*).—Cavernous voice manifests itself, if, in examining a patient in the act of speaking, the vocal vibrations seem to be concentrated in a hollow space, the walls of which reflect to the ear more or less distinctly articulated sounds. It is in general circumscribed at the superior portion of the chest, and coincides either with cavernous râle, or more particularly with cavernous respiration.

Cavernous voice indicates, like cavernous blowing, the existence of a pouch-like bronchial dilatation, or of a tuberculous, purulent, apoplectic, gangrenous or hydatid excavation. From the rare occurrence of bronchial dilatations and of pulmonary excavations, independently of phthisis, when contrasted with the frequent occurrence of caverns in cases of consumption, we conclude that, nine times out of ten, cavernous voice indicates a tubercular excavation.

E. *Amphoric voice.*—It is characterised by resonance completely resembling the hollow and metallic buzzing sound, produced by speaking into the mouth of a jug three parts empty. It announces the same diseases as amphoric respiration, with which it commonly coincides.

In those cases, where the voice of the patient becomes extinct or too feeble to resound in the chest, the physician may have resource to autophony, and endeavor to supply the absence of the ordinary local phenomena, by the modifications, which the resonance of his voice occasionally undergoes on applying the hand to the affected side.

ART. III. AUSCULTATION OF THE COUGH.

On applying the ear to the chest of a healthy person, we perceive, during the act of coughing, a dull and confused sound, accompanied by a shock, which produces vibration of the pectoral cavity. This phenomenon, composed of impulse and sound, is the more perceptible the greater its

proximity to the ear, or the greater the dimension of the bronchial tubes, and the more forcibly the patient coughs.

The cough heard over the larynx and trachea, and in persons with a narrow chest, at the root of the bronchiæ, gives besides, the sensation of hollowness, or of the air traversing a tube.

In the pathological state, the cough presents special characters: it is bronchial or tubular, cavernous and amphoric.

When the cough is tubular, the ear evinces the sensation, which a column of air would produce on traversing with great noise, force, and rapidity, tubes with solid, and, as it were, metallic walls. It manifests itself under the same conditions as bronchial respiration, and, when it is well marked, it indicates, almost to a certainty, pulmonary hepatization.

Cavernous cough consists in a louder, and especially in a more hollow resonance, than that of the normal cough. It is accompanied by a highly characteristic shock against the ear, and is one of the most positive signs of pulmonary caverns.

The amphoric cough, characterised by a very marked metallic resonance, indicates, along with amphoric respiration and voice, the existence of pneumo-hydrothorax, with perforation of the lung, or a very large pulmonary excavation.

Metallic Tinkling.

This sound is perfectly analagous to that, which is produced on striking gently with a pin, a cup of metal, glass, or porcelain, or by dropping a grain of sand into it. It accompanies the respiration and the voice, but it is generally more manifest during the cough.

Metallic tinkling may be heard in pneumo-hydrothorax, whether simple or complicated with pleuro-bronchial fistula, and in a large pulmonary excavation. But as the caverns are, from their size and disposition, scarcely capable of causing a manifest and constant metallic tinkling, and, as hydro-pneumothorax, without pulmonary perforation, is of still rarer occurrence, metallic tinkling is almost always the pathognomonic sign of a triple lesion, viz: of pneumothorax with liquid effusion, and fistulous communication of the pleura with the bronchiæ.

Sound of Thoracic Fluctuation.

In the physiological state, the succussion of the chest manifests no sound, but when there exists in the cavity of the pleura a liquid effusion with air, the collision of these fluids caused by shaking the trunk, or by the spontaneous movements of the patient, conveys to the ear of the auscultator, a sound of waves with metallic tone. This phenomenon, analogous to the sound produced by agitating a caraff half filled with water, is sometimes so distinct that it is heard at a distance; it accompanies almost always amphoric respiration and metallic tinkling, and indicates, like them, the existence of pneumo-hydrothorax, or of a very large pulmonary cavern.

AUSCULTATION OF THE LARYNX.

In the normal state, the respiratory sound heard in the larynx, exhibits a hollow and cavernous tone, the vocal resonance is at its maximum, and the cough conveys the sensation of air traversing with rapidity a hollow space.

In the pathological state, the laryngeal respiratory murmur is harsher and more grating, as in cases of acute or chronic laryngitis, or it is supplanted by a sound of whistling, in spasm or œdema of the glottis, in stridulous laryngitis, and in compression of the trachea; or by a sound of snoring, in simple or stridulous laryngitis, in laryngeal ulceration with swelling of the edges, which sound has frequently a metallic tone in croup. Sometimes we hear a sonorous cry in cases of laryngeal ulcerations with tumefaction of the edges.

In some cases, the ear perceives a laryngeal cavernous râle, for example, when the trachea and the larynx are filled with mucous; this râle may be more circumscribed, and be connected with the presence of mucous over an ulceration, or around a foreign body, which is arrested in the ventricles of the larynx, &c. Finally, in some rare cases, we hear a species of trembling, which indicates the existence of croup, with floating pseudo-membranes.

There exists yet another sign, peculiar to a great many diseases of the larynx, which is recognised, indeed, by the auscultation of the chest, but which should here be mentioned; we mean the diminution or complete abolition of the vesicular murmur. This phenomenon occurs during any al-

teration, involving a considerable obstacle to the introduction of the air into the air passages, on the one hand, by obstructing or contracting the diameter of the canals, (swelling, inflammation, vegetations, accidental products, foreign bodies, &c.); on the other, by compressing them from without, (cancerous tumours, cysts, aneurisms, &c.); finally by producing the occlusion more or less complete, of the superior orifice of the air tubes, (hypertrophy of the tonsils, polypus of the nasal fossæ, falling back upon the superior portion of the larynx, etc.)

CHAPTER II.

AUSCULTATION OF THE CIRCULATORY APPARATUS.

Comprises the auscultation of the *heart* and that of the *large vessels.*

ART. I. AUSCULTATION OF THE HEART.

§ 1. *Physiological Phenomena.*

When, in the normal state, we apply the ear to the precordial region, we hear a tic-tac formed by two successive sounds, which are repeated regularly from 60 to 80 times per minute.

The first of these sounds, which is dull, deep, and more prolonged than the second, coincides with the shock of the apex of the heart against the thorax, and immediately precedes the radial pulse; it has its maximum intensity between the 4th and 5th rib, below, and somewhat to the outside of the nipple. The second sound, which is sharper, shorter, and more superficial, has its maximum intensity nearly on a level with the third rib, and a little above, and to the right side of the nipple.

After the dull sound succeeds a short pause, then follows the sharp sound and the long pause; this together constitutes a complete pulsation. The pulsations, which, in the adult, are from 60 to 80, are more frequent in childhood; exercise, moral emotions, &c., also increase their rapidity. Their loudness varies with the energy and rapidity of the contractions of the heart, and, according to individual idiosyncracy, and the form of the thorax; they are more intense in nervous persons with a narrow and lean chest. Their extent is equally variable; they are distinctly heard at the precordial region, and diminish in proportion as we withdraw the ear from that part; they are less evident anteriorly on the right side, and still more so posteriorly on the left side, being altogether absent on the right posterior region. They vary like-

wise according as the surrounding organs are more or less capable of conducting sound. Their tone presents various shades of character, but they are always pure, and free from harshness or grating.

The mechanism of these sounds has been very differently explained. Reasoning and experiment have led us to the following conclusions:

The series of the motions of the heart begins with the contraction of the auricles, which is immediately followed by ventricular systole, and is in its turn succeeded by diastole.

The contraction of the ventricles coincides with the shock of the heart, and consequently with the dull sound, whereas, the second sound corresponds with their dilatation.

The first sound is produced by the muscular contraction of the ventricles, by the action of the auriculo-ventricular valves, and by the shock of the apex of the heart against the thorax.

The second sound is chiefly owing to the action of the sigmoid valves, caused by the counter-shock of the columns of blood propelled into the aorta and pulmonary artery, against their concave surface.

§ II. PATHOLOGICAL PHENOMENA.

In the morbid state, the sounds present various alterations in their seat, extent, intensity, rhythm, and tone; they may also be produced, accompanied, followed, or supplanted by abnormal sounds.

1. *Alterations in Seat.*

The sounds of the heart are sometimes displaced, so that their maximum no longer corresponds to the points we have indicated. These displacements may depend on lesions of the heart, of the pericardium, of the large vessels, or of the surrounding organs.

The descent of the two sounds may be owing to tumors situated at the base of the heart, causing its depression; their ascent may be owing to the elevation of the diaphragm; their lateral displacement to pleuritic effusions; their displacement backwards to tumors in the anterior mediastinum. General or partial hypertrophy may likewise increase the relative distance of the maximum of the two sounds, or displace them in different directions.

2. *Alterations in Intensity and Extent.*

Under certain circumstances, the pulsations are only discernible at the precordial region, and even then with difficulty, when they are too feeble, or too imperfectly transmitted to the ear. Sometimes, on the other hand, the sounds are loud and ringing; the ear, elevated at the region of the heart by the energetic contractions of the organ, perceives very distinctly the two sounds at all points of the thorax, sometimes even at a distance, when their intensity is sufficiently great, or their transmission very perfect; a diminution in the extent of the sounds may depend on atrophy of the heart, on concentric hypertrophy, on a state of feebleness, on local or general atony, and also on pulmonary emphysema.

An augmentation in the extent of the sounds depends on an increase in the volume of the heart, on nervous palpitations, or on a state of general morbid excitability, and also on alterations of the contiguous organs, such as pulmonary hepatization, tubercles, &c.

The increase in intensity is sometimes connected with dilatation of the cavities of the heart, with eccentric hypertrophy, with neurosis, (palpitations), &c. The diminution of the sound refers to the opposite conditions, to atrophy of the heart, to concentric hypertrophy, to softening of the organ, &c.

3. *Alterations in Rhythm.*

The sounds of the heart may be altered in their frequency, in their order of succession, and in the number of sounds, which correspond to each pulsation.

Not to mention the febrile state, where the frequency of the pulsations may increase to 140 or 150 per minute, there exist certain affections of the heart, hypertrophy, nervous palpitations, &c., where they exceed that number, and they are sometimes so hurried, that it is impossible to count them. The retardation of the pulsations, the number of which may decrease so low as 20, or even 16, is more generally connected with diseases of the encephalon, than with affections of the heart. The order of succession may be disturbed in very different ways: at one time, one of the sounds (commonly the first) is more prolonged, as we observe in cases of ventricular dilatation, of hypertrophy, with stricture of the

arterial orifices; at another, this prolongation refers to one of the pauses, (commonly the long one,) and may depend on an impediment, which the blood sustains in penetrating into the ventricles; as, for example, in the case of auriculo-ventricular stricture. Occasionally, we recognise an irregularity in the pulsations, which are at one time more rapid, at another slower, and experience sometimes a stoppage, the duration of which is equal to one rhythm, and constitutes what is called, an intermission. These perversions combine, moreover, in various ways, so that the pulsations become confused and tumultuous. The diseases, momentary or permanent, which are thus produced, are allied to simple derangement of the nervous system, or to organic alterations of various descriptions.

In regard to the number of sounds, we have sometimes a single one; for example, when the first is so prolonged, that it covers the second, a circumstance, which is only observed in cases, where it is transformed into an abnormal sound; sometimes, on the other hand, we hear three or four sounds, arising, probably, from a want of synchronism in the movements of the right and left heart, which manifold sound M. Bouillaud has only noticed, "in individuals laboring under stricture of one of the orifices of the heart, with induration of the valves, accompanied generally by the consequences of pericarditis."

4. *Alterations in Character.*

The sounds undergo various modifications relative to their tone; they are duller than in the natural state, in cases of hypertrophy, and sharper in attenuation of the walls of the heart, and these alterations in character may likewise depend (especially as regards the second sound) on lesions of the valves, on the supervening changes affecting their thickness or elasticity.

The dry, hard, parchment-like tone of the sounds, coincides frequently with a certain degree of condensation and rigidity of the valves; their hoarse and smothered tone seems to have reference chiefly to a state of softness or swelling of these membranous flaps.

The metallic tone, (metalic tinkling of the heart,) which is but rarely perceived, seems to depend on the shock of the apex of the heart against the internal surface of the fifth rib: it is occasionally connected with an increase in the energy of

the pulsations, or with an induration of the walls. These alterations in the character of the sounds indicate the first degree of various diseases in the valves and orifices, diseases, the existence of which are, at a more advanced period, revealed by abnormal sounds.

5. *Abnormal Sounds of the Heart.*

Abnormal Sounds, viz. those, of which there exists no trace in the physiological state, are divided into two groupes, the sounds of blowing, originating in the cavities of the heart, and the sounds of friction, formed exterior to the organ in the pericardium.

1*st* *Genus. Sound of Blowing.*

We comprise under this term, blowing, properly so called, the sounds of gentle blowing, of grating, filing, or sawing, and finally, musical sounds, such as whistling, whining, &c.

A. *Sound of blowing* (*bellows sound*). This is the most common of all abnormal sounds; its very name is its best definition. It is more or less gentle to the ear, single or double, according as it is perceived during systole only, or both during the contraction and dilatation of the heart. We observe the sound of blowing, 1st, in a great number of organic diseases of the heart, strictures of the orifices, alterations of the valves, (fibrous deposits, vegetations, insufficiency, &c.) hypertrophy with dilatation, endocarditis, &c. 2d. Indiseases with alteration of the blood, anemia, chlorosis, cachexia, &c. 3d. In nervous derangements of the heart, (palpitations,) &c.

If this sound of blowing can show itself in affections so numerous, and so entirely different, how may we be able to ascertain its proper signification? The problem to be solved, is as follows: a sound of cardiac blowing being given, does, or does there not exist, an organic disease of the heart?

In order to decide the first question, we have to examine progressively the character of the sound, the third, where it shows itself, its persistence, its progress, and, finally, the whole of its concomitant phenomena.

The sounds of blowing connected with an organic disease of the heart, are sometimes gentle to the ear, but more frequently harsh, and resemble the sounds of grating, filing, &c. On the contrary, the sounds of blowing, with absence of organic lesions, are almost always very gentle. The former

accompany the first or second third, the latter supplant always the first third, and never the second; the former being permanent, continue for months or years, the latter are generally intermittent and transient. The one undergoes gradual transformations from gentle blowing to musical sounds, as the diseases of the orifices become more serious and deeply seated; the other habitually preserve their character of gentleness, whatever may be their modifications in intensity.

Finally, the former are accompanied by local and general symptoms characteristic of an affection of the heart, (dulness on percussion, purring tremors, irregularities in the pulse, considerable œdema of the inferior extremities,) whereas, none of these phenomena occur in chlorosis or anemia, at least not with very marked or durable characters.

In short, the gentle tone of the sound, its coincidence with but one third of the heart (the first), its intermittence, or short duration, and the absence of concomitant phenomena, grouped pathognomonically, are, in general, the characters of blowing, which is independent of a physical lesion of the heart, whilst blowing, indicative of an organic alteration of the organ, exhibits generally opposite characters of coincidence with both thirds, or with the second only, of permanence, and of a combination with a cyclus of morbid phenomena.

The existence of a material lesion being admitted, how shall we ascertain its character? Now, the sounds of blowing, which depend on pericarditis, on hypertrophy, on the formation of a clot of blood in the cavities of the heart, are accompanied by particular signs, such as bulging of the chest, and dulness on percussion at the precordial region, diminution in the shock, with feebleness, and distant character of the sounds, (pericarditis,) dulness on percussion, increase in intensity of the sounds, and of the impulse, (hypertrophy,) sudden manifestation of the abnormal sound, smallness of the arterial pulse, (formation of clots.) These diseases being discarded, there remain for our diagnosis, only the diseases of the orifices and the valves, which, in regard to their principal effects, may be arranged into two species; viz. strictures, and insufficiencies.

How are we to know, whether there exists stricture or insufficiency? In order to reply to this question, let us observe, in the first place, that blowing during the first third, may indicate, either a stricture of the arterial orifices, (giving rise to an increase in the friction of the blood during its direct

progress,) or an auriculo-ventricular insufficiency, (which likewise occasions friction during the reflux of the sanguinary columns.) On the contrary, blowing during the second third may depend on an auriculo-ventricular stricture, or on arterial insufficiency.

The exact determination of the diseased orifice will then indicate the nature of the disease in question; if we determine, for example, that there exists a lesion of the arterial orifice, in a case, where blowing supplants the first sound of the heart, we have then established arterial stricture.

Now the seat of the disease is recognised by the appreciation of the place, where the maximum of the sound of blowing originates, and by this consideration, that it is propogated to the large vessels, or that it is not audible beyond the region of the heart. In fact, the blowing, which results from a lesion of the valves, has its maximum intensity above the nipple, at the base of the heart, and may be propagated to the large arteries; whereas blowing, which depends on an alteration of the auriculo-ventricular valves, has its maximum below the nipple, nearer to the apex of the heart, and is not propagated to the large arterial trunks.

Accordingly, if blowing, during the first third, have its maximum at the apex of the organ without propagation to the large arterial trunks, it indicates auriculo-ventricular insufficiency, and, on the other hand, if the same blowing have its maximum at the base of the heart, and be propogated to the large arteries, it is the sign of arterial stricture. Again, blowing during the second third, with its maximum intensity below the nipple, and without propogation to the large arterial trunks, indicates auriculo-ventricular stricture; whereas the same sound, with the maximum above the nipple, and with propogation to the large arteries, is a sign of insufficiency of the arterial valves.

After having determined the species of diseased orifice, and the nature of the lesion, we have only further to decide, whether the alteration belong to the right heart, or to the left. We arrive at the solution of this problem by the examination of the relative seat of the abnormal sound on one side of the heart, and by its comparison with the normal sounds on the other; we know, that the conditions capable of producing blowing exist on both sides, so that one of the two sounds may be altered in the left heart, and remain normal in the right heart, and vice versa. Accordingly, if we hear for example, on any point of the left side, the maximum of

an abnormal sound, while we discover the natural sound more towards the right, we have to conclude, that the lesion and the blowing, which reveals it, belong to the left heart, and *vice versa*. Moreover, the diagnosis of the diseases of the left cavities is chiefly confirmed by the existence of alterations in the pulse, and that of affections in the right cavities by the disturbance of the circulation in the large veins, and more particularly in the jugular veins.

We have hitherto supposed, that there exists single blowing at the precordial region; let us now suppose, that it is double. A double sound of blowing may be connected with the four following conditions: 1st. Arterial stricture and insufficiency; 2d. Auriculo-ventricular insufficiency and stricture; 3d. Arterial, and auriculo-ventricular stricture of both orifices; 4th. Insufficiency of both orifices.

The same considerations, derived from the seat of blowing from its propagation, etc., serve also to determine, what species of lesions exist.

We remark, farther, that the four complex lesions just indicated, are not equally common, and that the diseases of the valves involving stricture, (such as thickening and induration of these membranous flaps), are often capable of causing their insufficiency. We have therefore to conclude, that a double sound of blowing is in general a more positive sign of a double lesion of a single orifice, than of two lesions, the one situated at the arterial, and the other at the auriculo-ventricular orifice. Again, since auriculo-ventricular stricture exists pretty frequently without abnormal sound, it follows, that the double sound, considered independently of the other elements of diagnosis, indicates rather an arterial stricture and insufficiency, than any of the three other combined alterations, and since diseases of the valves are much more common on the left side than on the right, a double sound of blowing announces generally a stricture of the aortic orifice, with insufficiency of the sigmoid valves.

B. *Sounds of grating, filing sawing.*—These abnormal sounds, of which their very name gives a pretty correct idea, supplant most frequently the first sound of the heart; they are sometimes double, and obscure both the first and second sound. They are permanent, of long duration, and continue so soon as they are well established; we see them afterwards more commonly transformed into musical sounds. They are almost always accompanied by vibratory tremors, (purring tremors), which are appreciable by the hand.

They indicate almost constantly organic alterations of the orifices of the heart, and more frequently strictures than insufficiences. Their character of harshness indicates in general a greater friction, and consequently, lesions more developed, than those interpreted by simple sounds of blowing: these are most commonly cartilaginous, osseous, or osseo-calcareous indurations.

C. *Musical sounds*, (*whistling*, *whining*).—Under some circumstances, we hear not merely sonorous but real musical tones, analogous to whistling, to cooing, or to the sibilant râle of bronchitis. According to M. Bouillaud, these sounds are nothing but the sounds of blowing raised to a higher pitch, and exhibiting a shriller tone, for they pre-suppose, in their extreme degrees, nearly the same physical conditions. Indeed they are allied to deep-seated lesions of the valves, and especially to considerable strictures of the aortic orifice, produced by osseous or calcareous degeneration of the semilunar valves.

2d *Genus. Sounds of Friction.*

Pericardial friction.—Under the generic name of sounds of pericardial friction, we classify several phenomena, which have a considerable analogy to the various species of pleuritic friction, and which are produced by similar anatomical conditions. Thus we distinguish gentle rustling from harsh friction or crackling, which is somewhat analagous to the sound of grating, from the sound of new leather, which imitates the creaking of a new sole under the movements of the foot, and from the sound of rasping, which is a still harsher species of friction, and seems in reality to be produced by the rasping of a very hard and almost cartilaginous or osseous body against the surface of the pericardium.

The sound of friction indicates the existence of pericarditis with false membranes, and with coincidence of a small quantity of liquid.—*Rustling* indicates, according to M. Bouillaud, "that the opposite folds of the pericardium, dry, and somewhat viscid as happens in incipient pericarditis, are not yet lined by false membranes;" or that the pseudo-membranous exudation is recent, soft, thin, and somewhat corrugated. *Harsh friction* implies, that the pseudo-membranes are thicker, more reticulated, uneven and rough.—*The sound of new leather* denotes, in general, that they are firmer, more resisting, elastic, and, perhaps, already partially transformed into

adhesions incessantly subjected to more or less brisk and violent tugging during the motions of the heart (Bouillaud). Finally, the sound of rasping coincides with the formation of hard or morbid products, such as cartilaginous or osseous deposits in the pseudo-membrane, osseo-calcareous laminæ, developed in the parietal pericardium, or also calcareous concretions lodged between the fibres of the heart, and causing protuberances under the serous membrane with which they are covered.

ART. II. AUSCULTATION OF THE ARTERIES.

In the normal state, while exploring in a healthy adult, and during the period of repose, an artery of a certain volume, as, for instance, the crural artery, we hear, during each arterial dilatation, a slight murmur, somewhat sonorous and almost dull, a murmur *sui generis*. This sound, which is short and somewhat intense, is in each artery synchronous with the pulsations of the vessel, the jerking motion of which is sensible to the touch; it is solitary, (except in the carotid artery, where it appears double, in consequence of the transmission of the sound of the heart), and it is repeated from 60 to 80 times per minute, and at equal intervals. It is in general the more intense, the larger the volume of the vessel, the more active the circulation, the greater the pressure exercised by the stethoscope, &c.

In the morbid state, the arterial sound is transformed into single and intermittent blowing (blowing with a single current), or into continuous blowing (blowing with a double current), which has sometimes a particular tone, humming-top sound, (*bruit de diable*), occasionally we hear musical sounds variously modulated, (the chant of the arteries).

A. *Sound of blowing.*—This sound, likewise called the sound of intermittent blowing, conveys to the ear the sensation of gentle blowing, analogous to that produced by compressing the carotid artery with the stethoscope, it corresponds with arterial diastole, and offers different shades of intensity and character. It is more frequently met with in woman than in man, and occurs more commonly in the carotid than in the crural arteries, and more rarely on the left side than on the right.

The sound of arterial blowing manifests itself in cases of aneurisms, of organic stricture of the arteries, or of compression of the vessel by some tumour; it is then in general lo-

cal, and not heard beyond the trunk, where it originates, or it propagates at the most to the neighboring large branches. It is sometimes connected with the existence of certain alterations of the blood (anemia, chlorosis, cachexia, &c.), and it has then the tendency to spread over a greater or smaller number of arteries, when it constitutes merely a phenomenon of transmission of cardiac blowing, it is recognised by its coincidence with the signs furnished by the auscultation of the heart.

B. *Continuous blowing.*—This blowing with a double current is composed of two sounds, the former of which coincides with arterial diastole, and is louder than the latter, which corresponds with arterial systole. It offers various shades of intensity, and in its highest degree it resembles the sound produced by lashing the top, known by the name of the *devil*, and constitutes, then, the humming-top sound. These two sounds have their favorite seat in the carotid and sub-clavicular arteries, they are both connected with alterations of the blood, and the humming-top sound, in particular, is a sure sign of chlorosis.

Musical sounds.—In some cases, the abnormal sounds of the arteries have a truly musical tone, and constitute the melodious whistling of Laennec, or the chant of the arteries of M. Bouillaud. The sounds, which the ear then perceives, have been sucessively compared to those of the Jew's harp, to the buzzing of an insect (fly's sound) to the resonance of the tuning fork, &c. They generally coincide with the diastole of the heart, and with the systole, during which they commonly increase in intensity, and assume a shriller tone. They are only sometimes perceived in the crural and subclavian arteries, and almost exclusively in the carotids. They occur more frequently on the right than on the left side, and on one side than on both together. They also show themselves more frequently in females than in males. These musical sounds, the mechanism of which is of very difficult explanation, are like sounds of blowing with a double current, an almost infallible sign of alterations in the blood, chlorosis, or constitutional anemia.

APPENDIX OF NOTES.

Note A.—P. 3.

M. Prus has proved, by calculation, that nearly half the number of old people die from diseases of the chest; (*Gazette Med.* 1838, p. 217,) a similar statistic account has given us a still greater proportion in regard to children; and we remark, in addition, that as the affections of the heart are of very rare occurrence in childhood, death is, at that period of life, almost exclusively caused by pulmonary lesions.

Note B.—P. 9.

It is perhaps not of very material consequence, of what kind of wood the stethoscope is formed, nor what particular shape may be given to it. It seems, however, advisable, that its interposition should, on acoustic principles, be at least as little prejudicial to the transmission of sound as possible.

It is with this view I am in the habit of using a stethoscope made of a species of wood, the fibres of which are loose and regular, and without any interruption.

It is indispensable, that the wood of the cylinder should be continued through the ear disc, as it has thus the advantage of being part of an uninterrupted conductor of the same density throughout.

The ear disc may be made of any suitable material, and it should be of considerable size, as one of its objects is to communicate the tremors to the bones of the head.

See paper on this subject by Professor Forbes, in the London and Edinburgh Monthly Jour. of Med. Science.—*Trans.*

Note C.—P. 9.

I am enabled, through the kindness of my friend Dr. Bennett, to communicate the following note, which I give nearly in his own words: "I have been for some time in the habit of using a percussor, which I first saw employed by Professor Barez of Berlin. It is the invention of Dr. Winterich of Wurzburg, who published a description of it in the Berlin

Med. Central-Zeitung, for January, 1841. It is a small hammer, consisting of a head or body of metal and a handle of wood. At the extremity of the former, a capsule is screwed on with a round perforation in it, and in its interior is a condensed cylinder of caoutchouc, which projects through the opening, and during percussion comes in contact with the pleximeter. Care should be taken, that the projecting caoutchouc is firm, smooth. and of equal roundness. The handle is furnished with small hollows, in which the thumb and two fingers should be placed when it is used. The finger of the left hand may be employed as a pleximeter, but it will be found much better to use one made of ivory, wood, or metal. The one I recommend is a modification of that invented by M. Piorry. The modification consists in the instrument being oval instead of round, and much reduced in dimensions. The shortest diameter is one inch, and the longest one inch and three quarters. An inch and a half scale ought to be engraved upon it, which will be found very useful in measuring the extent of any dulness which may be present. The form of the pleximeter now described, enables the practitioner to apply it to certain points of the chest with more facility, as above the clavicles, the intercostal spaces, &c., especially in emaciated persons. With the above instrument, the student may at once commence percussing, without experiencing any of those difficulties he so frequently encounters in acquiring the necessary dexterity with the finger. The hospital physician will find, that the employment of this instrument is less fatiguing, and that the sounds produced are much louder and clearer than can be elicited by the fingers, whilst the inconvenience or pain suffered by the patient is much less."

I have not had much experience in the use of the hammer and pleximeter, and believe that the physician, who is in the habit of employing the finger of the right hand as the precussor, and that of the left as the pleximeter, will not feel inclined to make any change.—*Trans.*

Note D.—P. 15.

It may appear to some that many of the preceding directions for the employment of auscultation, are unnecessarily minute and tedious, the more so, when it is considered that in practice every one soon finds out, for himself, what is the most complete and satisfactory method of procedure. As, however, the work is professedly a practical one, and will fall, for the most part, into the hands of those commencing

the study of auscultation, it has been thought better to retain every thing as set forth in the original.—*Trans.*

Note E.—P. 15.

M. Fournet has overrated this difference, when, in his work, otherwise so excellent, (*Recherches cliniques sur l'auscultation des organes respiratoires,*) he has represented the inspiration by the figure 10 and the expiration by 2, or as 5 to 1. The difference of intensity and of continuance during the two periods of respiration is explained, moreover, very well by the difference of force expended upon each. M. Fournet is satisfied by manometric experiments, that the force of expansion exercised by inspiration is equal to 10, and the force of contraction exercised by expiration to 5.

Note F.—P. 19.

"The tracheal respiratory sounds can be produced," says M. Beau, "*without the air circulating in the air passages.*" Does he not thus contradict a statement, which he makes afterwards? "In order that the tracheal and vesicular sound be produced in the fifth experiment, the individual must not shut the glottis, and he must feel the *free circulation of air in the larynx.*"

Note G.—P. 19.

In an elastic body, the sound is louder in proportion to the rapidity of the vibrations.—*Physique de Beudant*, p. 183.

Note H.—P. 23.

"I know a man affected with asthma, in consequence of dilatation of the ventricles of the heart, whose respiration can generally be heard at the distance of twenty paces, while the noise produced within his chest during respiration, is not so loud as is observed in the majority of men.—*Laennec*, T. I. p. 69.

Note I.—P. 25.

"Having heard, on blowing without noise into the lungs, a vesicular sound, although a feeble one, and having perceived that this has taken place in individuals, who exhibited no guttural sounds during respiration, I admit that the pulmonary cells produce, during expansion or contraction, a slight respiratory murmur."—*Piorry, Tratié de diag.* T. I. p. 469.

Note K.—P. 25.

The difference of tone presented by sounds, produced in canals of different texture, depend, first, upon the nature of this texture, and their manifestation appears to be the result of the friction of the column of air against the walls, and perhaps, also, of a certain feeble resonance of the walls themselves."—*Beudant*, p. 370.

Note L.—P. 25.

Dr. Skoda, in his work (*Die Perkussion und Auscultation*), is of opinion, that the variable intensity of the voice transmitted through the substance of the lung, is not explicable by the laws, which regulate the more or less rapid propagation of sounds through different media, but that it depends on the laws of consonance, which consists in the fact, that, under the proper conditions, a body performing a certain number of vibrations, may induce another body in its neighborhood to vibrate in unison (consonance) with it. In support of this view, he appeals to the following experiments:—

1. On placing a hollow wooden cylinder upon a watch exactly fitted to its aperture, and on examining with the ear at the other extremity, we perceive the sound of the *tic-tac*, simultaneously through the wood, and through the air contained in the tube. Having then filled up the hollow by a wooden cylinder, and examining, as before, the tic-tac becomes much less distinctly audible; hence it follows, that the air is a better conductor of sounds than solid substances.

2. On speaking through the stethoscope, placed on a portion of normal pulmonary tissue, and directing a person to examine, at the same time, through another stethoscope, applied at various distances from the former, the sounds are more distinctly heard, than when the same experiment is performed on a portion of hepatized lung. But the difference is much too inconsiderable to account for the remarkable augmentation in intensity of the thoracic voice.

This greater resonance of the voice is not, therefore, referable to the increased conducting powers of the condensed pulmonary tissue, but to consonating vibrations of the air contained in the morbidly affected organs of respiration, and to the walls of these latter being rendered more susceptible of vibratory movements, in consequence of the greater density of the surrounding parenchyma. Accordingly, consonance takes place—1. In all morbid processes where the

substance of the lung, owing to infiltration of foreign matter, has become void of air, dense and solid. 2. When the cartilages of the bronchial branches, which enter into the substance of the lungs, have increased in size and density. 3. In the case of pulmonary excavations, and dilatations of the bronchia, the walls of which begin to reflect sounds, as soon as the surrounding parenchyma becomes sufficiently dense or infiltrated.—*Trans.*

Note M.—P. 27.

M. Petrequin (*Revue médicale*, March, 1838,) has endeavored to produce the stethoscopic phenomena in the dead body: by means of bellows fitted to the trachea he introduces air into the lungs, either removed from the chest, or remaining in the body, and imitates with their rhythm, the unequal acts of inspiration and expiration. He has been able thus artificially to produce the vesicular murmur, as also the râles and sounds of blowing, by injecting the lungs with liquids of different densities. He could also imitate several physical lesions, as pneumo-thorax, pneumo-hydrothorax, and produce metallic tinkling, amphoric respiration, &c. M. Petrequin has proposed the adoption of this *artificial auscultation* instead of the examination on the living subject. M. Piorry had already, in 1828 (*de la percussion médiate*,) shown the advantages of this method, and since then, several observers have employed it.

Note N.—P. 31.

The result of M. Fournet's manometric experiments shows, that the intensity of the sounds of respiration is in direct proportion to the force of the movements of the chest.—(*loco cit.*, p. 150.)

Note O.—P. 31.

In the same experiments, when the patient was made to breathe into the manometric apparatus, the vesicular sounds were observed to diminish and disappear altogether, in proportion as the air in the apparatus becoming exhausted, a diminished quantity reached the pulmonary cells.—(p. 334.)

Note P.—P. 32.

It is necessary, that all these conditions be fulfilled, in order to derive a positive diagnosis from auscultation, for, as we have already remarked, the acoustic phenomenon is only one of the elements in the problem, to the solution of which every

other method must contribute. But it is easy to imagine, that in reference to each stethoscopic sign, we cannot mention all the other data, which may augment or diminish its value, without passing into numerous repetitions, and unnecessarily increasing the bulk of our work. We shall be satisfied with recalling to mind the principal circumstances, which, for the most part make the difference between affections, whose material expression has some points of analogy.

Note R.—P. 33.

If we insist upon the absolute or relative *semeiological value* of stethoscopic phenomena, it is not because we presume to set down axioms in auscultation, but because we have thought it better for practical purposes, to present, under the form of aphorisms, propositions, which, though subject to exceptions like almost every pathological *law*, are true in an immense majority of cases.

Note S.—P. 37.

"We hear, during inspiration and expiration, a slight but very distinct murmur, which indicates the penetration of the air into the pulmonary tissue, and its expulsion." (*Laennec*, t. I. p. 20, *ed. Andral*). Speaking afterwards of the respiration of children, he mentions the fact, that with them the difference in intensity of the vesicular murmur exists principally during inspiration, and that it is much less marked in expiration.—(p. 64.)

Note T.—P. 43.

M. Grisolles (*de la pneumonie, Journ. hebdom.*, No. 29, 1836,) mentions a variety of not very noisy *bronchial respiration*, which conveys to the ear the *sensation accompanying the tearing a piece of taffetas.* It appears to him to depend, from what he has observed in the dead body, upon the induration of a superficial layer of lung.

Note U.—P. 43.

The intensity of a sound, (Beudant, p. 183), its tone, or elevation of pitch, depend on the number of vibrations produced in a given time; the higher tone corresponds to a greater, the lower to a smaller number: a double rapidity gives the octave. (*Physique de Pelletan*, 1838, t. I. p. 542.)

NOTE V.—P. 43.

Every sound is caused by vibrations in the body, where it originates. Each vibration supposes a certain degree of elasticity. (*Magendie*, Leçons sur les phenomenes physiques de la vie, t. I. p. 266.) The sound is much more intensely heard through the medium of a solid body, than through that of the air.—(*Beudant*, p. 201.)

NOTE W.—P. 43.

The intensity of the sound is proportioned to the size of the sonorous body, to the amplitude of its vibrations, to the number of bodies vibrating in unison with it, and finally, to the degree of silence, which prevails around it.–(*Beudant*, p. 183.)

NOTE X.—P. 47.

These conclusions, chiefly applicable to the adult, are less so to children. With the latter, pneumonia, which is generally disseminated (lobular pneumonia) gives rise to less distinct bronchial respiration; moreover, as the inflammation is frequently double, the ear of the observer does not perceive that striking contrast which exists in lobar pneumonia of adults, between the normal or merely exaggerated respiration of the healthy side, and between the blowing on the diseased side.

NOTE Y.—P. 47.

Laennec has described (*Laennec, ed. Andral*, p. 79,) a variety of cavernous or bronchial respiration, which he designated by the term *blowing*, and where the air seems to be drawn from the ear of the observer during inspiration, and to be driven against it during expiration. This phenomenon implies, that the excavation, or the bronchia, where it occurs, lies near the surface of the lung. This blowing respiration sometimes presents an appearance, as if the air agitated a moveable veil, interposed between the ear and a pulmonary excavation. This *veiled blowing* seems to be connected with an unequal density of the walls of the cavern, where it is produced. This latter variety, on account of its rariety and trifling diagnostic value, has but little engaged the attention of observers.

NOTE Z.—P. 48.

Dr. Skoda rejects Laennec's distinction between cavernous and bronchial respiration, on the ground, that there ex-

ists no marked and constant sign to inform us, when the air enters into excavations larger than the branches of the bronchiæ.—*Trans.*

Note 2 A.—P. 49.

The remarks, we make here and elsewhere, in regard to tuberculous caverns being chiefly situated at the apex of the lung, must be slightly modified, when considering the phthisis of children. With them, excavations exist far less exclusively at the central or inferior portion of the lung, than in adults. This circumstance is, to a certain extent, explained, by the frequent occurrence of tubercular deposition in the bronchial ganglions. These glands, which accompany the bronchiæ down to the parenchyma, may be primarily the seat of a tuberculous degeneration; subsequently, they begin to soften, cause ulceration of the pulmonary tissue, which surrounds them, and being then brought into communication with the bronchiæ, they form cavities, which differ from pulmonary caverns, only by their seat and mode of developement.

Note 2 B.—P. 49.

Laennec fancied, that to produce amphoric resonance and metallic tickling, the cavity should contain both air and fluid, but Dr. Skoda contradicts this, by remarking, that the jug may be perfectly dry and empty, and yet exhibit both phenomena with the same readiness. On speaking through the stethoscope, applied to an inflated stomach, metallic tinkling, and amphoric resonance, are distinctly audible, whether that organ contain fluid or not.—*Trans.*

Note 2 C.—P. 50.

The physical cause of the production of respiration was extremely well illustrated in a case communicated by me to the Anatomical Society, and published in "the Report of Cases" for 1824, in the Edinburgh Medical and Surgical Journal. The tuberculous cavity was so large as to be capable of containing from a pint and a half, to two pints of fluid; the walls were smooth, and communicated with the bronchiæ.—*Trans.*

Note 2 D.—P. 61.

We do not pretend to give an appellation to all the minute shades of sounds produced in the air passages; the most diversified terminology could not characterise so many delicate

or vague sensations; we have only kept in view the principal varieties, lest we should become tedious. M. Piorry has correctly observed, that the classification of râles is like that of animals and vegetables in natural history; there exists in the greater number of cases no distinct line of demarcation, which separates them, and they form an ascending series, the degrees of which it is difficult to specify. The illustrations we are about to give will demonstrate, that the practical object of our work has imposed upon us, the caution not to multiply subdivisions, *ad infinitum.*

Note 2 E.—P. 67.

Hourmann and Dechambre *de la pneumonie chez les vieillards.*

Note 2 F.—P. 69.

It is probably this variety which M. Fournet has described under the name of *moist râle with continuous bubbles*, and which he considers as the pathognomonic sign of active pulmonary congestion; we do not think that this *shade* of the râle possesses sufficiently distinct characters to deserve being made a particular *species.*

Note 2 G.—P. 70.

Dr. Skoda maintains that Laennec's distinction between mucous and cavernous râle, is not satisfactory, for the size and abundance of the bubbles depends on the quantity and quantity of the liquid contained in the bronchiæ or excavations, and on the force of the current of the air; again, the circumscribed character of the cavernous râle is a very equivocal sign, since, if excavations occur throughout the whole of the lung, instead of being limited to a narrow space, the râle becomes audible over the whole surface of the affected side; moreover, if a râle with large and abundant bubbles, be produced in a single large bronchiæ lying superficially, how can we distinguish it from the cavernous râle of Laennec.—*Trans.*

Note 2 H.—P. 73.

We ought to recollect, that those principles may undergo some modifications, *ex.* when the thorax is deformed by rachitis. Accordingly, the chest of children is sometimes observed to be contracted laterally, and antero-posteriorly, by a depression resembling a vertical furrow which corresponds

with the articulation of the cartilages with the ribs; hence results a species of strangulation of the lung, which favors, as MM. Rilliet and Barthez have observed, (*Journ. de Connaiss. Med. Chir.*, April, 1840,) the engorgement of the lung and the accumulation of mucous matter at its posterior portion. Hence the more easy formation of moist râles which we should be careful not to over-value. Moreover, in some adults affected with distinct deviations in the vertebral column, with contraction of one side of the thorax, and protrusion of the opposite side, it is no unusual circumstance to recognise moist râles, which are produced with more facility, or which predominate on one side, so that these differences would not bear the same importance to the diagnosis, which they would have done in a well formed individual.

Note 2 I.—P. 79.

Laennec's dry crepitating râle, with large bubbles, or dry crackling, is, according to Dr. Skoda, produced by the sudden tension of the walls of the air cells, of the bronchiæ, or excavations during the act of inspiration, on the supposition that these walls collapse passively during expiration, instead of being vitally contracted, for it is certain that the lung may lose its power of contraction, without giving rise to a remarkable enlargement of individual air cells, because all the cells are uniformly distended.—*Trans.*

Note 2 K.—P. 79.

M. Fournet says that he recognised it in eight out of ten cases of tubercular affection.

Note 2 L.—P. 83.

The signs which we generally derive from auscultation of the voice, are, for the most part, absent in young children, in certain patients, such as lunatics and aphonous persons, &c, So that, if the observer takes the part of speaking upon himself, at the same that he holds the ear close to the chest, his own voice resounds, undergoing, in certain cases, modifications corresponding to the alterations of the organs, and assuming, for example, a *bleating* tone in pleurisy. This remark, already made by M. Taupin (*Revue Med.*, June, 1839,) had been disregarded and left without application. M. Hourmann has proposed to put it into practice (*Revue Med.*, July, 1839,) and has given the name of *autophony* to this new

mode of auscultation. We have tried this method, and we are doubtful that it will become of really useful application, both on account of the rare occurrence of the circumstances requiring its employment, and more particularly on account of its uncertainty.

Note 2 M.—P. 85.

The morbid resonance of the voice has numerous degrees of intensity, from slight resonance to the ringing sound which is really painful to the ear. We cannot distinguish each of them by special terms, though the transition from natural vocal resonance to its maximum, is gradually affected. Similarily as in respiration, which, from the normal type, passes to the state of *harshness*, and assumes afterwards the *bronchial* character, we admit two degrees of vocal resonance:—1st. *The exaggerated resonance.* 2d. *Bronchophony*, properly so called. Moreover, as these two modifications differ only in intensity, and as their pathological significations depends on the character, more or less developed, of the lesion, we shall say but little on simple *resonance*, and the following chapter will be the necessary compliment of the present one.

Note 2 N.—P. 90.

Dr. Skoda remarks, on the subject of ægophony, that it is almost impossible not to confound it with that species of bronchophony which partakes of the bleating character, and consequently that it remains doubtful whether we have to treat a case of pneumonia with pleuritic effusion, of which ægophony is said to be the characteristic sign, or of pneumonia without effusion. In fact, the simple ægophony of Laennec has, according to Dr. Skoda's own experience, manifested itself in cases where the pleuritic effusion was considerable, in cases of pneumonia, of tubercular infiltration of the pulmonary parenchyma, with and without excavation; and inversely, pleuritic effusion has frequently taken place, while the resonance of the thoracic voice exhibited no bleating character,—add to this, that in some cases of hydrothorax, and pneumonia without pleuritic effusion, the bleating sound only accompanied some words and syllables, and was entirely absent in others.—*Trans.*

Note 2 O.—P. 94.

Another advantage of this new designation, consists, in establishing between the phenomena furnished by the ausculta-

tion of the voice, the same relative terminology, which we have used in regard to the alterations of the respiratory sound, and which we shall use for the cough: accordingly we would treat of *bronchial* or *tubular*, *cavernous*, and *amphoric respiration;* of *bronchial* or *tubular*, *cavernous* and *amphoric voice;* of *bronchial* or *tubular*, *cavernous*, and *amphoric cough*. Notwithstanding this substitution of terms, we shall oocasionally employ the word pectoriloquy; but we do not attach the same meaning to it as Laennec, and shall only consider it as synonymous with the other.

Note 2 P.—P. 95.

The resonance is owing to the reflection of the sound from the surface of the obstacle, encountered by the vibrations; it frequently results, likewise, from the vibration of the walls against which the sonorous wave is propelled.–*Beudant*, p. 371.

Note 2 Q.—P. 96.

The chapters which treat of amphoric respiration, amphoric voice, and metallic tinkling, are so indistinctly connected, that their combination is sometimes of use to investigation and practical application.—Vide pp. 71 and 147.

Note 2 R.—P. 112.

Laennec has, besides, mentioned another method of exploration; he advises (and he has himself adopted the practice in several circumstances) the employment of percussion and auscultation at the same time. On speaking of the signs which may reveal the existence of pneumothorax, he expresses himself as follows: "we may also estimate the extent of the space occupied by the air, by employing auscultation and percussion at the same time in different points, we then hear a resonance similar to that of an empty cask, which is momentarily mingled with tinkling."—(T. I., p. 139.)

Note 2 S.—P. 118.

We do not mean the pathological phenomena furnished by the *laryngeal voice* and *cough*, because the study of these belongs more especially to auscultation *at a distance.*

Note 2 T.—P. 126.

It is generally said that the pulse is synchronous with the first sound of the heart, or with the impulse of the apex of that organ against the thorax: this is a mistake; it is sufficient

to make the experiment in an individual whose pulsations are somewhat slow, in order to assure ourselves by the touch, that the arterial pulsations take place during the intervals of the two sounds, and the more closely upon the first sound, the nearer to the heart the artery is situated. Vivisections confirm this clinical observation; the Committee of Dublin have ascertained, that the synchronism which exists in the large vessels springing from the heart is the less perfect, the more remote the arteries are from the central organ of circulation. Accordingly, " by causing the blood to issue from the punctured pulmonary artery, and from the right ventricle, we become satisfied that both jets take place at the same instant; on repeating the same experiment on one of the mesenteric arteries, we arrive at a different result; the blood is observed to flow from the artery at an appreciable period of time after it escapes from the aperture made in the ventricle."

Note 2 U.—P. 127.

The following statistic data bear upon this topic.—M. Lediberder has examined the heart even before the umbilical cord was divided; he has found, during the first minute which follows the expulsion of the fœtus, an average number of 83 pulsations; but he cannot regard this number as the expression of the normal state, because at the moment when the child is born, the respiration is not yet established, and indeed the pulsations become more rapid in proportion as this function begins to accomplished; after the third minute, they amount to the mean number of 160. (*Valleix, clin. des. mal. des nouveax nés*, p. 26.) The average number of pulsations stated by authors as regards new born children, varies considerably: amongst the more recent observers M. Valleix has given the number of 87; M. Jacquemier that of 126, and M. Naegele that of 135. In children from two to three years old we have most frequently found a total, varying from 75 to 90. MM. Leuret et Mitivié (*Archives*, Feb. 1833, p. 308,) conclude from their statistic accounts, that the pulsations of the heart are, (contrary to the general opinion), of greater frequency in old persons than in adults. According to the researches of W. Guy, (*Guy's Hospital Reports*, Oct. 1838), it appears that in women the pulsations of the heart exceed the average number in man, by from 10 to 14 per min. In regard to the influence of positions, the upright posture, according in the same author, increases by about a dozen the numbers

of pulsations witnessed in the horizontal decubitus. It is also well known that the circulation is remarkably accelerated after taking food.

Note 2 V.—P. 144.

These two eminent physicians who have extended the dominion of the stethoscopic science, by their useful labors, equally claim the priority of the above discoveries, in regard to which honor we shall forbear making any remarks.

Note 2 W.—P. 144.

We make no mention of the first experiments, which are foreign to this subject.

Note 2 X.—P. 148.

Dr. Skoda founds his view of the cause of the sounds of the heart on the following observations:—1st. Single or double blowing is sometimes heard over the left ventricle and over the aorta, at the same time that the sounds continue over the right ventricle and pulmonary artery. 2d. Blowing is occasionally perceived over the left and right ventricle, or over the right ventricle and aorta, whilst the sounds are distinctly audible at all the other parts when blowing is absent. 3d. Single or double blowing is frequently heard along the course of the aorta, whilst both sounds are discernible over the right and left ventricle, and over the pulmonary artery; hence it follows, that the right and left ventricles, the aorta and pulmonary artery, are, independently, capable of producing either sound.—*Trans.*

Note 2 Y.—P. 149.

Dr. Skoda explains the shock of the heart by the well-known physical law, that a fluid contained in a vessel presses its walls equally on all sides, and that, if it be allowed to escape through an aperture, it ceases to press on that point, but continues to do so on the point opposite; hence the vessel receives a tendency to move in a direction contrary to the induced current. In a similar manner, during the contraction of the ventricles, the pressure of the blood against that portion of the walls, which is opposite to the aortic orifice, induces a motion of the heart in a direction contrary to its progress through that orifice. The only exceptions inexplicable by this physical law are: a double, or even triple pulsation of the heart during a single pulsation, and weakness of the pulse during a powerful impulse, in cases

when the valves are in a healthy condition. These phenomena demonstrate, that the shock may also take place independently of the expulsion of the blood from the ventricles, and that it is sometimes greater than can be reasonably expected from the small quantity of ejected blood. May it not be possible that the muscular fibres of the heart are disposed in such a manner, as, lever-like, to raise the apex of the heart towards the walls of the thorax? or may not the shock be accomplished by the ventricles assuming a more spherical form during systole, whilst they lie flat during diastole?—*Trans.*

Note 2 Z.—P. 151.

We shall not regret having given a more complete account of the theories hitherto advanced than any other author has done, and having discussed them at large, if, on the one hand, we have succeeded in clearing up a complex and obscure question, and if, on the other, by mentioning the positive facts, which might alone to be our guide, we have furnished to those~~, who~~ should be tempted to contrive other theories, the elements which can assist them in their reasonings, and prevent them from wandering.

Note 3 A.—P. 154.

It is scarcely necessary to advert here to those local changes which are consecutive to congenital malformation to transposition of the viscera, &c.

Note 3 B. 157.

Laennec, some days before he died of the *tuberculous* affection which too prematurely deprived science of its great support, heard very distinctly the pulsations of his heart; having ascertained that his stomach was distended with gas, he fancied that the phenomenon was to be attributed to this pneumatosis, in which idea he was confirmed by the fact, that eructation caused the cessation of the sounds.

Note 3 C.—P. 162.

In order that the inverse conditions should take place, and that the first sound should disappear, we have to suppose, as coinciding with the second third, a sound of blowing so prolonged that it fills up the long pause, and obscures, moreover, the systolic sound; observation proves, however, that this is never the case.

Note 3 D.—P. 163.

Dr. Hope says, (*loco cit.* p. 41), he has uniformly remarked, that in some patients two sounds are heard during the first third, and he explains this phenomenon in following manner: in very lean persons the apex of the heart strikes, during the contraction of the ventricles, the inferior edge of the fifth rib, which projects into the interior of the chest, hence arises a *costal* sound which is purely accidental (the impulse against the thorax being aphonous in the physiological state): as the shock of the point of the organ takes place only a short time after the first sound, this costal sound, which assumes, moreover, sometimes a metallic tone, succeeds the ventricular, and makes it appear as double.

Note 3 E.—P. 172.

Direct experiments made by M. Piorry (*Trait. de diag.*, T. I. p. 133). by the Committee of Dublin, (*the Dublin Journal of Med. Science*, t. I. p. 449), and by other observers, of which we shall give the results in the chapter on auscultation of the arteries, show that the abnormal sounds of the heart, are explicable, like those of the arteries and veins, by mollecular friction of the particles of blood, put in motion in the circulating apparatus.

Note 3 F.—P. 174.

M. Jacquemier (*Thèses de la fac de Paris*, 1837, No. 466.) has published curious researches on this subject; out of 257 pregnant women in whose cases he performed the auscultation of the precordial region, and who exhibited, moreover, no sign of general disease, or of organic lesion of the heart, he recognized in 62 instances an alteration of the sound caused by blowing; 130 women delivered, he found the same stethoscopic phenomenon only 23 times, and not more than twice in 7 unimpregnated females who appeared to be in excellent health; so that, according to his calculations, the proportion of blowing (he never heard the musical sounds, grating, sawing, &c.) to the normal sounds of the heart, would be, that of 1 to nearly 4 during pregnancy, that of 1 to 6 after delivery, and that of 1 to 35 in young unimpregnated females, in a state of health.

Note 3 G.—P. 183.

This chapter on the sounds of blowing had been completed some time ago, when we observed in the second edi-

tion of the work of Dr. Hope, the statement of those considerations which we have just detailed. If we wished to vindicate the priority, as regards the observation of the facts here specified, we would mention, that we have explained them already in our lectures delivered in 1836 and 1837, that M. Chomel, to whom we had communicated them, has made them public in his Clinical reports, 1839, and, finally, we would refer the reader to a note by M. Andral, (t. III. p. 237, ed. Laennec); but, setting aside these personal questions, we congratulate ourselves that an observer like Dr. Hope arrived at the same conclusion, and that these results of our researches and reflections received the sanction of his experience.

Note 3 H.—P. 186.

"In other cases I have heard, in the same region, but more deeply situated, a sound similar to the creaking of leather of a new saddle under the rider.—I thought for some time that this sound might be a sound of pericarditis, but I have since convinced myself that it is not."

Note 3 I.—P. 194.

On the carotid arteries we have most commonly *two sounds*, the sound which is frequently the loudest is merely the transmission of the second sound of the heart, and we may, therefore, pass it without notice.

Note 3 K.—P. 197.

According to Dr. Hope, (*loco cit.* p. 109.) all the sounds which we call *arterial*, have their seat in the veins, and ought, consequently; to be called *venous*. On the neck, they take place, according to this author, in the internal and external jugular veins, and when, the murmur is more dull and feeble, in the smaller and deep-seated veins. The reasons on which Dr. Hope founds this hypothesis, have not been able to convince us.

Note 3 L.—P. 206.

In diseases of the abdomen, as in those of several organs which yet remain to be considered, auscultation is far from having rendered the same services, as in affections of the chest, where it has produced a complete revolution in the semeiology of the diseases peculiar to the circulatory and respiratory apparatus, it is here limited to but a few indications, the value of which is far inferior to that of the other dedu-

cible or sensible signs. We do not, therefore, think it necessary to insist on these various applications of the discoveries of Laennec, reserving to ourselves a more minute investigation of the stethoscopic phenomena, relative to pregnancy.

Note 3 M.—P. 207.

Laennec had, moreover, announced, that in *ascites*, the stethoscope applied to the abdomen transmitted to the ear, the shock of the liquid put in motion by percussion.

Note 3 N.—P. 214.

M. Ménière, physician of the Royal Institution for the Deaf and Dumb, has had the kindness to communicate to us the following note, which contains a summary, and gives a more complete view of Laennec's observations on the application of stethoscopy to the diagnosis of diseases of the ear.

Note 3 O.—P. 221.

M. Nægele, jun., points out another sound, consisting in blowing, synchronous with the pulsations of the fœtus, but simple, which is produced by the pulsations of the umbilical cord. He has observed it in cases of twisting, and falling forward of the cord, or only during the presence of this vascular body, between the back of the fœtus and the uterine walls; the reality of this phenomenon is not generally admitted, and several authors believe that the blowing perceived in some cases, is nothing else than an abnormal sound of the heart of the fœtus.

There exists yet another sound, indicated by Dr. Stoltz, which we shall merely mention; it consists in "a dull and irregular whizzing, like the sound of fermentation; it had been observed in several women who were delivered of dead children; and Dr. Stoltz thinks that it is to be attributed to the decomposition of the fœtus, and the waters of the aminos.

Note 3 P.—P. 230.

M. Depaul has verified the reality of the cardiac blowing of the fœtus, for in three cases where it had been observed during intra-uterine life, he could find it again in the children after their birth.

Note 3 Q.—P. 237.

The nomenclature of the positions of the fœtus, which is here followed, is that of the school of Baudelocque. The

first position of the head, as alluded to in the text, is that in which the face looks backwards to the right sacro-iliac synchondrosis; the *fifth* in which the face looks forwards to the right foramen ovale. Again, the *second* position signifies the face turned backwards to the left sacro-iliac synchondrosis; the *fourth*, the face turned towards the left foramen ovale.

Note 3 R.—P. 239.

Professor Simpson informs me, that when Bouillaud's doctrine of the placental blowing was first published, Mr. Scott and he made, in reference to it, a number of experiments similar to those indicated in the text, p. 216. In several cases of pregnant females near the full term of gestation, (and who were selected for the observations, in consequence of the distinctness and localization of the placental sound,) they endeavoured, by every possible change of position of the bodies of the mothers, to change the degree of pressure made by the uterus upon the iliac arteries, but they found they were unable, by these means, to alter the exact position and degree of distinctness of the sound in question. A different result would certainly have followed, if the mere compression of the iliac arteries had been the source of the sound.

Professor Simpson has met with two large abdominal tumours, having a sound similar to the placental blowing very distinctly marked in them. In one of these cases, the sound is limited to a space on one side of the umbilicus; in the other, it is much more diffuse. In both instances, various correlative symptoms show, that the diseased masses are formed by very large fibrous tumours of the uterus. The uterine parietes are often greatly hypertrophied around fibrous tumours, and upon a section sometimes present an appearance of vascular and muscular hypertrophy, very exactly resembling the walls of the organ in a state of advanced pregnancy. May this analogy in the vascular structure of the organ, under these two different conditions, account for the occasional identity in the sounds that are elicited?

As far as we are aware, the first, and, probably, the only case in which auscultation has hitherto been employed in the diagnosis of extra-uterine pregnancy, occurred four years ago, in the practice of Drs. Girdwood and Tennant of Falkirk. There was a large irregular tumour rising high into the abdomen, and between, and between this and a lower tumour (the enlarged tumour), the aorta could be felt. Drs. Girdwood and Tennant easily discovered the first and higher

mass to be formed, by distinctly ascertaining in it, the characteristic and rapid pulsations of the fœtal heart. Professor Simpson was called to see case, with the view to the propriety of performing the Cæsarian section; but, by the time he arrived, the child was evidently dead. The mother died two years afterwards, of an acute cerebral disease, when a full grown fœtus was formed in the cavity of the peritonaeum. The fœtus, uterus, &c., are preserved in the Midwifery Museum, of the University.—*Trans.*

APPENDIX.

OBSERVATIONS ON TUBERCLE AND THE TUBERCULAR DIATHESIS.

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[It has been thought that some account of the chief points in the Pathology of Tubercle, would not be inappropriate, nor without its use, as an Appendix to an elementary treatise on Auscultation. No attempt will be made, however, to write an elaborate essay; on the contrary, the ensuing observations are designed to embrace only the leadiug features of the pathology, but omitting entirely the more ordinary phenomena connected with the tuberculous deposits. In other terms, it will comprise an outline of the general pathology and therapeutics of tubercle and the tubercular diathesis.]

1. The history of tubercle is replete with obscure speculations and contradictory opinions. And these differences relate not alone to the more intangible changes composing its general pathology, but they are equally numerous in regard to the solid deposits, which readily admit of inspection. It has been declared with the greatest confidence to be organic and inorganic, vascular and non-vascular, inflammatory and non-inflammatory; and, indeed, it has been made to assume, according to the fancy of the observer, almost every form of morbid action. These differences of opinion have arisen, mainly, from opposing and imperfect views of its general pathology, and likewise from including within the definition of tubercle products properly belonging to another class.

2. Laennec regarded tubercle as in some sense a lesion of nutrition; that it depended on an anterior and general derangement of the constitution; and that it was deposited as a secretion independent of inflammation. He recognized two varieties: the first was the gray or semi-transparent, including the granulations of Bayle; the second, the yellow or crude tubercle; and he further conceived, that the gray species was ultimately transformed into the yellow variety. Louis agrees with Laennec, that gray tubercle is changed into the yellow

variety; but he admits that the latter may be deposited without having been preceded by the former. Sir James Clark, Dr. Carswell, and pathologists very generally, entertain the opinion that gray tubercle may be transformed into the crude or yellow variety; but it is admitted by Dr. Carswell, that some of the gray deposits which have been arranged under this head, differ, in some instances, from legitimate tubercle. The identity of tubercle and the granulations of Bayle, is not universally admitted. Andral, and others, regard these granules as the product of chronic inflammation of the air-vesicles, and therefore widely different from tubercle.

3. It has long been a question among pathologists, whether tubercle owes its origin to inflammatory or non-inflammatory action; whether it is organic or inorganic; vascular or non-vascular. It will at once be perceived, that these questions are intimately associated, if they do not, indeed, constitute so many links in a chain; so that the answer to one may be regarded as an elucidation of the others. Still it becomes important to note the evidences for and against each proposition. At the present time, the weight of authority is decidedly in favor of the opinion which assigns tubercle to the class of inorganic and non-vascular deposits, which approach the characters of dead animal matter, and which are not necessarily the result of inflammation. Still there are many respectabe pathologists who entertain opposite views; and as most of our opinions in relation to the origin, nature, and results of tubercle, depend very greatly on the solutions of these questions, it becomes exceedingly important that they should be accurately and definitely settled. And if well authenticated facts have not sufficiently accumulated to solve every difficulty and to remove all doubts, it is still important to study with care and to arrange with precision, those observations which are most entitled to confidence.

1. *Is Tubercle Organic or Inorganic.*

4. In attempting to solve this question, the first consideration that should engage the attention of the pathologist, relates to the nature of the deposit itself. Without entering into detail, it may be briefly stated, that almost all chemists who have carefully analyzed tubercular deposits, agree in opinion that they are *essentially albuminous*. Fibrin has also been detected, but in quantities bearing a very low proportion to the albumen. Hetcht, it is true, concludes that the

proportions of albumen, fibrin, and gelatin are nearly equal; but it does not appear that others have been able to arrive at similar results. The conclusions, therefore, derived from the concurrent testimony of the most accurate chemists, cannot be invalidated, nor even suspected of inaccuracy, by a single opposing analysis. So general, indeed, is the opinion, that tubercular deposits are composed mainly of albumen, that we are obliged by the common conventional rules of science, to regard the subject as definitely and conclusively settled.

5. The next important inquiry relates to the *microscopic* appearances of tubercle. In regard to the minute structure of tubercle observers have differed somewhat; but nevertheless there is a sufficient agreement among those who are most entitled to confidence, to relieve the subject from most of its uncertainty. In Gerber's General Anatomy, Mr. Gulliver has delineated the minute structure of tubercle, a portion of which he conceives to be made up of "irregular corpuscles." And he further adds: "A very minute granular matter is situated between the corpuscles and cells, which indeed it often seems to pervade.* In a general sense, these statements agree with my own investigations; but it seems probable that Mr. Gulliver has been too positive in regard to the presence of nucleated cells; or, at least, that his phraseology might lead to doubts and inferences foreign to the best authenticated opinions on the subject. But admitting the existence of these cells, it does not necessarily follow that they possess the character of those which are susceptible of organization, for Mr. Gulliver himself designates them as "irregular," which is certainly very far from representing the true nucleated organizable cell.

6. My own observations on the structure of tubercle, have been made with one of Ross' microscopes, an instrument of remarkable defining power. Carefully examined with this instrument, tuberculous matter magnified 500 linear diameters, constantly presented the appearance of its *main mass* being composed of *granules* much smaller than true nucleated cells; and interspersed through this granular mass, were apparent cells of larger dimensions; but upon careful inspection it appeared that these larger bodies were made up of an aggregation of the smaller granules. These minute granules thus united to form the larger masses, might readily be mistaken for nucleated cells; for they exhibit very much the ap-

*Atlas, p. 61.

pearance of cells containing nuclei. This view explains the term "irregular" employed by Mr. Gulliver in his description of these masses; for it is very plain that their size and shape will depend on the number of granules which may happen to be united. And Mr. Gulliver himself seems to have made nearly the same observation, for he remarks, that these minute granules often seem to pervade the entire masses. It is not improbable, moreover, that epithelium cells and mucous corpuscles have sometimes been included in the description of tubercle; as these bodies may readily become intermixed with tubercle when it has been derived from the mucous or serous tissues.

7. Additional observations made by Mr. Gulliver very conclusively show, that his authority is opposed to the supposition that tubercle contains organizable cells. In his *Appendix* to Gerber's General Anatomy, p. 85, it is distinctly stated, that tubercle most frequently exhibits *no regular structure*, and that it is composed of *granular* matter, minute *spherules*, and *shapeless flakes;* and those bodies which he denominates *cells*, are admitted to *disappear*, and probably *degenerate* into *corpuscles*, as the tubercle advances. But if any doubt still remained in relation to this accurate observer's opinions, the following extract, (*Appendix*, p. 87,) would prove conclusive: "Tubercle, however, seems to differ essentially from the matter of plastic exudations, inasmuch as the cells of the latter not only grow into a higher organization, but increase also in number towards the centre; in other words, plastic matter has an inherent power of multiplying and evolving organic germs. But tubercle has no such power; for it would appear that its primitive cells can only retrograde and degenerate, since they are wholly destitute from the beginning of plastic force." It may here be added, that in plastic matter, referred to in the preceding extract, true nucleated cells exist, and these become the instruments by which organization is effected; and in all instances, without any exception, if the exudation be destitute of these peculiar bodies, organization is wholly impossible.

8. Authority might be multiplied, but it is deemed unnecessary to enter into more detail, further than to add, that Dr. J. Hughes Bennet, of Edinburgh, declares that he has been unable to detect any form of nucleated cells in tubercle. He regards the granules which make up its substance as undeveloped cells, which have no tendency to organization, but which break down into molecular matter. This view we

conceive is fully borne out by all of the facts bearing on the structure of tubercle, and, indeed, so indubitable as scarcely to admit of a doubt.

9. Evidence has already been introduced to show (§4,) that tubercle is essentially albuminous; and when this fact is connected with the well known law that fibrin only is capable of organization; and that even the latter substance requires the presence of nucleated cells to accomplish the change; every possible evidence is adduced to prove that tubercle is inorganic. And if to this testimony we add the fact, that the most careful injections have failed to display any thing approaching vascular structure in tubercle, the evidence becomes wholly irrefragable.

10. Although it is abundantly evident, that tubercle is insusceptible of organization, it is at the same time not improbable that it possesses a low degree of vitality. The elementary granules which enter into its composition, appear to be indued with some degree of organic force; this vitality, however, is of a subordinate character, being too low to admit of organization; but it is sufficient to resist, for a time, the tendency to decomposition, and therefore the mass maintains a solid form. This feature in the character of tubercle may serve to explain the remarkable disparity which exists between different species in undergoing decomposition; some varieties possess more vitality than others, and therefore maintain a state of solidity for a much longer period.

11. Finally: It has been shown that tuberculous deposits are essentially albuminous; that tubercle is composed mainly of *granules*, which may be regarded as undeveloped cells; that true nucleated cells if present at all are in such small numbers, and otherwise so modified, that organization is prevented; that injections fail to exhibit vessels in tubercles; and therefore, that tubercle is strictly an inorganic and non-vascular substance, and either remains in the organ where first deposited, as a substance foreign to the tissue of the part, or it disintegrates, forming a molecular mass which is eliminated.

2. *Is Tubercle of Inflammatory Origin.*

12. The question of the inflammatory or non-inflammatory origin of tubercle, might be summarily disposed of by appealing to the preceding arguments; for it is exceedingly improbable that veritable inflammation would give rise to abuminous and granular deposits only, when lymph and cells are

its appropriate and ordinary products. And a similar conclusion might be reached by appealing to authority, for the names of Laennec, Louis, Andral, Carswell, Clark, Rokitansky, etc., should have no small influence in the formation of our opinions; but remembering that a considerable number of respectable pathologists still contend for the opposite opinion, and as the question is of the highest importance, it becomes an interesting subject for investigation.

13. In general terms, the non-inflammatory origin of tubercle may be inferred from its existence without that condition. It has been repeadedly proven in the most satisfactory manner, that tubercle can be deposited in the various organs, and in different stages of development, entirely independent of any appreciable sign of inflammation in the surrounding tissues. If, therefore, the deposit takes place without the ordinary local evidences of inflammation, it would surely be unauthorized and unphilosophical to assume that which could not be demonstrated; and more especially would such an assumption be unwarranted, when it is remembered that the ordinary secernent action of the parts is amply sufficient to explain the disease, without seeking the intervention of inflammatory action. It may be remarked, moreover, that not only are the usual morbid appearance wanting to prove the existence of inflammation, but that the symptoms existing anterior to death are equally negative; so that tubercle may be deposited without producing, or being accompanied by, any rational evidence of inflammation, or the usual post-mortem signs of that condition. And it is worthy of observation, that when the tubercular diathesis is strongly developed, the deposits may take place in almost every organ of the body at the same time; but it would scarcely come within the limits of probability, that inflammation would simultaneously attack such a large number of organs; and as such an event is extremely improbable, if not impossible, the fact itself becomes peculiarly instructive.

14. Additional evidences of the non-inflammatory character of tubercle, may be derived from the location of these morbid actions. It has been fully established by extensive observation, that pneumonitis more frequently attacks the right than the left lung; and that the lower lobes are invaded in preference to the apex. And we have the authority of Louis for the statement, that tubercular deposits, on the contrary, are most frequent in the left lung; and it is a fact familiar to every one, that the apex of the lung is its common

location.—The inferences from these facts is obvious: inflammation most frequently attacks the lower lobes of the right lung; tubercle is more commonly seated in the left side, and almost always at the apex; therefore, the habits peculiar to these morbid actions are dissimilar, and they are regular by-laws at least widely differing, if not absolutely adverse.

15. Every morbid action has its own peculiar products; exudation of serum results from congestion; the secretion of coagulable lymph from inflammation; and the peculiar element of cancer from its own organization. And it is impossible for congestion to produce coagulable lymph or that mere inflammation should originate cancer. Now the production of tubercle is as much an effect of a peculiar action as either of the morbid changes mentioned; and it would be a violation of all analogy and sound reasoning to infer, that it could be produced by a mere state of inflammation. And the dilemma could not be obviated by the position, that inflammation is acting on a tuberculous constitution; for however greatly the process and products of inflammation may be *modified* by diathesis, it is scarcely probable that they would be *entirely changed*; and hence, the most that could be anticipated under such circumstances, would be a limited change, and not an entire substitution of another product, such as that of tubercle. It will be stated more fully in another paragraph, that chronic pneumonitis, even in the tuberculous diathesis, is apt to produce a local effusion somewhat different from tubercle; a deposit which seems to be elevated in the vital scale by inflammation, and therefore to be capable of maintaining an independent existence much longer than can be done by mere tubercle. It should also be noted, that inflammatory products contain *nucleated cells*, which tend to organization; but on the contrary, tubercle contains *granules*, wholly insusceptible of becoming an organized texture (§5). This distinguishing mark between these classes of products is peculiarly instructive, if not conclusive in the premises.

16. It is a well known law of pathology, that during inflammatory action, fibrin is always increased in quantity; and when this increase does not take place during a given morbid process, it is a rational inference that inflammation is not present. Now it has been stated by Andral, that fibrin is *increased* in phthisis; and his authority has been quoted to show that inflammation existed; but upon accurate examination it will be found, that this increase of fibrin did not occur until

the stage of softening supervened, and was most abundant in the more advanced stages. This statement is strong corroborative evidence that tubercle it not inflammatory; for when first deposited there is no increase of fibrin, which shows the absence of inflammation; but as the disease advances, and inflammatory action becomes developed, then fibrin makes its appearance, proportioned to the extent of the inflammation. The investigations of Andral, therefore, go far to prove, that tubercle is not deposited under inflammatory action.

17. Finally: The non-inflammatory character of tubercle may be inferred—1. From its being found post-mortem without any inflammatory action, and without having been complicated with symptoms of inflammation during life. 2. From its attacking numerous organs at the same time. 3. From the more common location of inflammation in the right lung and tubercle in the left—the former at the base and the latter at the apex. 4. From the character of inflammatory secretion, which consists of fibrin and cells, whereas tubercle is composed of albumen and granules.

3. *Nature of Tubercular Deposits.*

18. In accordance with the principles advanced in the preceding paragraphs, the conclusion is reached, that tubercle is inorganic and not of inflammatory origin. The fact that it is frequently connected with excited vascular action is by no means proof that the deposit is of an inflammatory nature; on the contrary, the most indubitable evidence can be adduced to prove, that the complication is accidental or secondary, and not fundamental. The distinguishing and characteristic products resulting from the various forms of morbid action have already been referred to (§ 15); and it is important to bear in mind these general laws, for it is by their aid alone that we are enabled to classify the several deposits, which have at one time or another been mistaken for tubercle.

19. Tubercle may be thus defined: It is an inorganic, nonvascular deposit, composed mainly of albumen in which numerous granules exist; it is deposited as a morbid secretion or exudation, not necessarily connected with inflammation. Two varieties of tubercle are included in this definition,—the gray semi-transparent, and the yellow. These two varieties possess the same general properties, chemical and vital; they differ, however, in several particulars which deserve notice.

20. It has already been intimated (§10), that tubercle is not

absolutely dead animal matter. Various considerations might be adduced to sustain this position; but it will perhaps be sufficient to allude to the well known ability of certain forms of tubercle to resist decomposition. This is especially the case with the gray variety; and it not only possesses this property, but it likewise may, under some circumstances, undergo *contraction*, showing conclusively that it has obeyed the laws vital action, and not those of inorganic matter. The granules entering into the composition of tubercle may be considered undeveloped cells; and just in proportion to their defective development, so will be their want of vitality; but as they are not entirely *destroyed*, they retain some degree of vitality, and may therefore maintain a limited period of existence. It would appear from the duration of the two forms, that the granules and albumen which enter into the composition of the gray variety, possess a higher degree of vitality than the yellow species; and it is by virtue of this quality that the former can resist decomposition for a longer time, and may even undergo contraction and remain stationary for an indefinite period. But the yellow variety appears to have lost nearly all vitality, and is therefore but little more than dead animal matter which speedily passes into softening and disintegration.

21. The differences, therefore, between the two forms of tubercle specified, depend chiefly upon the degree of vitality remaining in the granules effused with the albumen; in the gray species, the vitality is higher, and in the yellow, the lowest; but in all instances, the *tendency* is to decomposition, although that result may be retarded by various circumstances. When the deposits are small, and occur in constitutions in which the diathesis is not very greatly developed, they are usually of the higher grade, and do not tend to rapid softening. And when the deposits are in the form of miliary tubercles, they are so surrounded by the healthy tissues, that their feeble vitality is sustained, and they may remain latent for a long period.

4. *Relationships between Inflammatory and Tuberculous Deposits.*

22. The products which characterize inflammation and tuberculosis, as has been stated in the preceding paragraphs, are widely different. But notwithstanding the entire truth of these statements, a careful exposition of the subject renders it equally apparent, that a certain relationship may be traced

between these two actions; and under some conditions this relation becomes so near an identity, that it is yet a question to which class certain products appropriately belong. Thus the granulations of Bayle were regarded by Laennec as the first stage of tubercle; but on the contrary, Andral is equally positive that they are the products of inflammation. And when we remember the character of the processes concerned, it is not surprising that these discrepances should exist. The exudation appropriate to inflammation consists of fibrin and certain cells, the two combined being capable of organization; tuberculosis gives rise to to the effusion of albumen and granules, which are incapable of forming organic structures. A certain relationship will be observed between these two processes. Fibrin is nothing more than albumen more highly elaborated; and the difference between the cells of inflammation, and the granules of tubercle, depends on the latter being imperfectly developed, which destroys the organizing force. The difference, therefore, consists chiefly in degree; *but it is the difference between an organic and an inorganic deposit.*

23. A brief reference to general principles may here be useful. It has been very clearly established by modern physiological investigations, that all organic tissues owe their origin to the presence of primary nucleated cells; and for the purpose of fully securing organization, these cells must exist in suitable numbers, and healthy qualities, or the process will either be impaired or entirely suspended. And it should be remarked also, that nucleated cells possess not only the property of transformation into tissues, but they are likewise indued with some degree of individual vitality; and by virtue of this last vitality, they may, for a time, maintain an independent existence. In other words, several aggregated cells in contact with living tissues, can maintain a state of existence without passing into absolute organization, or without containing vessels; and their ability to live without vessels depends on cell-absorption, by which they obtain a supply of nutriment sufficient for their sustenance.

24. The vitality of cells varies according to circumstances. In those instances in which they do not come up to a healthy standard, there may still be a sufficient supply of nutriment, through a few vessels, but more particularly by cell-absorption, to prevent decomposition. If the vitality of the substance be raised one degree above this point, it will become vascular and perfectly organized; if it sink much below, its

nutrition fails, and disintegration follows. This last result is peculiar to tubercle; and how far it may be connected with inflammatory deposits, is not very certain; and, indeed, its occurrence under the latter circumstances is not very clearly established. It is difficult to conceive that, in a healthy constitution, inflammation will give rise to a product the tendency of which is to decomposition; and if it occur in a tubercular constitution, the product can no longer be said to be the legitimate offspring of inflammation. It appears, therefore, that the lymph produced by inflammation tends to more or less perfect organization, when deposited in contact with healthy living solids; that it results either in true vascularity, or in that lower form of vitality to which reference has been made. It constitutes no objection to the preceding arguments, that in pleurisy, for example, flakes of lymph, apparently incapable of organization, are found floating in the serum; for in many instances these flakes are mostly albuminous; but independent of this consideration, it is probable that if these same portions of lymph had been deposited in the tissues of the lung, surrounded by living structures, instead of floating in a collection of serum, they would have attained at least a low degree of organic action.

25. That variety of plastic material which takes on a low form of organization, is described by Dr. Williams under the term *cacoplastic* deposit, which signifies a substance imperfectly organizable; and according to the view of that author, it is the same material which forms cicatrices; fibro-cartilaginous, and fibro-cellular formations connected with serous and cellular tissues; and also those interstitial deposits constituting granular degeneration of the liver and kidneys.* These deposits are imperfectly organized, but still they possess sufficient vitality to resist decomposition.

26. Guided by the preceding general principles, we are now prepared, in some measure, to separate the inflammatory from tuberculous deposits. And in the first place, based upon this mode of classification, we remove the pulmonary granulations of Bayle from their association with tubercles, and arrange them with the inflammatory products. Andral has long since pointed out the true nature of pulmonary granulations, and he has shown that they result from chronic pneumonitis affecting the air-cells. And in the first place we may adduce as evidence of the truth of this opinion, that the granulations

*Principles of Medicine, etc., p. 308.

are developed in connection with pneumonitis, and not alone under circumstances favoring the production of tubercle. These granules are obviously produced in the air-cells, and are formed by the thickening of the cells themselves, and the deposition of lymph; and hence they are not met with any other tissue, exactly in the same form.

27. Further evidence of the inflammatory character of granulations may be derived from their location. Tubercle, as has previously been stated (§14), usually occupies the summit of the lungs; but in opposition to this, granulations are dispersed throughout the pulmonary structure generally, but are more abundant in the lower lobes. A specimen now under my observation is peculiarly instructive on these points. The history of the case proved it to have been one of chronic pneumonitis; but subsequently acute disease supervened, which proved fatal. The apex of the lungs were measurably free from the granules, but they existed abundantly in the lower lobes; and moreover, the acute inflammation was most intense at the same point, showing that a transition from the chronic to the acute stage had taken place. Finally, the granulations produced by injecting mercury into the air-cells, in the experiments made by Cruveilhier, were subsequently ascertained, by the aid of the microscope, to consist of inflammatory products.

28. In addition to the granulations of Bayle, various other forms of inflammatory deposits are met with in the lungs, variously modified in different instances. These occur in chronic pneumonitis; and one of the chief characteristics of these productions is, their indurated texture,—or, at least, indurated as compared with hepatization resulting from acute pneumonitis. This form of pneumonic deposit approaches, in its general appearance, the gray variety of tubercle; and as the distinction between these products is not very obvious, they are doubtless frequently mistaken for each other. These masses seem to be imperfectly organized, but they possess a low state of vitality, which is maintained by some degree of vascularity, and by cell absorption. These deposits are formed under the same general circumstances which produce pulmonary granulations; and the chief difference between them is, that granulations form in the air-cells, while the masses accumulate and remove all appearance of cells. As distinguished from tubercle, these deposits occur independent of the tubercular diathesis; they are deposited in masses gen-

erally larger than those of gray tubercle; they are always associated with inflammation; are located in the lower lobes; and finally, it is most probable that they do not soften.

29. It is evident from the preceding observations, that the similarity in appearance between the higher orders of tubercle and the lower species of inflammatory deposits, is so remarkable, that they may readily be blended in the same definition. And although the pathological conditions giving rise to these substances are widely different, yet the low form of inflammation connected with the the one, and the obstruction and secondary irritation associated with the other, present so many points of similarity in the general symptoms, and even morbid appearances, that it becomes no easy task to make the true distinction.

30. Dr. Addison* has drawn attention to the connection between tubercular and inflammatory products; but while he has pointed out several important considerations, he has fallen into the great error of classing true inflammatory deposits under the head of phthisis. He divides Phthisis into *three* varieties: 1. *Pneumonic Phthisis; 2. Tuberculo-pneumonic Phthisis; 3. Tubercular Phthisis.* The first variety is purely the product of inflammation; the second is a combination of inflammatory and tuberculous deposits; while the third represents true tubercular phthisis. In conformity with this arrangemnnt, two forms of tubercle are recognized—the sthenic and the asthenic; the sthenic corresponds to the grey, and the asthenic to the yellow tubercle. The sthenic variety occurs in what he calls *tuberculo-pneumonic phthisis*, and manifest but little tendency to disintegration; the asthenic form constitutes the true *tubercular phthisis*, and is remarkably prone to decomposition. If we get Dr. Addison's idea correctly, it is this: There are three varieties of deposits which may take on softening, constituting three forms of Phthisis. The *first* is a deposit from inflammation, (*Pneumonic-phthisis*); the *second* is also a product of inflammation, but is associated with true tubercle, (*Tuberculo-pneumonic Phthisis*); the *third* is true or yellow tubercle, (*Tubercular Phthisis*). The first two constitute the gray semi-transparent tubercle, the second the yellow tubercle.

31. The great errors in Dr. Addison's description, consist in these: 1. That he has arranged the products of chronic inflammation under the head of Phthisis; 2. That his tuber-

*Guy's Hospital Reports, No. V. 1845.

culo-pneumonic phthisis is nothing more than an accidental complication of inflammation and tubercle. The inflammatory products which he mentions, are identical with those refferred to as the result of chronic pneumonia (§27); and, therefore, cannot properly be arranged under any modification of Phthisis.

32. The second variety mentioned by Dr. Addison, Tuberculo-pneumonic Phthisis, is that form of disease which is well known to occur as a complication of inflammation and tubercular deposit. It is a common observation, that these two forms of disease are frequently associated, but it cannot be supposed that it is more than an incidental occurrence. The true solution of this connection may be referred to one of two conditions—1. The tubercular diathesis previously existing, inflammation becomes an exciting cause of the tubercule deposit. 2. The deposit having occurred first, *it* becomes the exciting cause of inflammation. So that, what would seem to be a necessary and natural association, is in reality an accidental complication.

33. The disease which Sir James Clark denominates "Febrile Phthisis" admits of a similar explanation. In this affection the invasion is sudden, and usually follows undue exposure to cold; it occurs in the tubercular diathesis; and it is ushered in by the ordinary symptoms of febrile disease, together with those of pneumonitis and Phthisis. The deposits in such cases are less frequently in the summit of the lungs, than occurs in uncomplicated Phthisis. These features clearly indicate that the *active* disease is *pneumonitis;* but as it occurs in a tuberculous constitution, it becomes an exciting cause of tubercle, and hence the two forms of products will be found associated in the same lung.

34. Finally: It appears from the preceding observations, that the relationships between inflammatory and tuberculous deposits, consist--1. In an effusion of cacoplastic lymph,--lymph of a low grade of vitality,—which does not take on ordinary vascular action, but which possesses, nevertheless, sufficient vitality to resist decomposition. This material is doubtless often mistaken for tubercle, in consequence of its similarity in external appearance; but inasmuch as it is the product of inflammation, may occur in constitutions not tubercular, and manifests no tendency to disintegration, we are authorized to class it with the products of inflammation—2. The second point of relationship is, that inflammation occurring in the tubercular diathesis, may become an exciting cause of Phthisis; and on the contrary, the deposition of tubercle very

commonly excites inflammation; so that these two conditions may excite each other into activity, and produce substances peculiar to both.

5. *The Sources of Tubercle, or the Tubercular Diathesis.*

35. Much anxiety has been manifested by pathologists, to determine whether tubercle existed in the blood, as such. It has been supposed by some that they have detected the tuberculous matter floating in the blood; others have been less successful, and declare their inability to discover any such material. The observations previously made in regard to the nature of tubercle, would lead us to anticipate, that no substance resembling solid tubercle could exist in the blood. We have already seen that tubercle is composed mainly of albumen; and it is beyond question that the albumen is derived from the blood; it is abundantly obvious, however, that no particular portion of the blood can be designated as tuberculous, but that it is derived from the mass of albuminous matter generally. While, therefore, the elements from which tubercle is derived continue to circulate in the blood, they present a fluid, homogeneous appearance, and exhibit no resemblance to tubercle; but when a portion of this substance, namely, the depraved albumen, is deposited in particular tissues and becomes concrete, then, and not till then, can tuberculous matter be detected. In other words, albumen from which tubercle is derived, exhibits while in the blood nothing more than the ordinary properties and appearances of fluid albumen; but when deposited in the tissues as inorganic bodies, then it assumes the character of tubercle. It is therefore futile to seek for a substance in the blood possessing the characters of tubercle.

36. The attention of the pathologist is often directed to the healthy structures and functions for the purpose of explaining diseased actions; and in no single instance pertaining to the human system, is a knowledge of healthy actions more important for the purpose of learning the exact source of morbid changes, than in tuberculous affections. And to those healthy actions which become impaired in the tuberculous diathesis, our attention will now be briefly directed.

37. All nutriment undergoes the process of digestion and assimilation; and however diversified the nature of food may be, it is ultimately reduced to the same peculiar element. The obvious difference which exists between food and the

textures of the organs into which it is transformed, clearly exhibits the great and important changes which alimentary substances undergo. The process of assimilation is, therefore, exceedingly complex; digestion, or the solution of food in the stomach, is the starting point; assimilation, or its conversion into tissues and organs, is the termination; and between these extreme points, a series of progressive changes take place, which prepares the digested fluid for assimilation. It is obvious that alimentary substances merely in solution, cannot at once be transformed into structures, and hence the necessity for further change; and it is equally apparrent, that if this change should not be effected, nutrition will be proportionally impaired.

38. It has previously been remarked (§ 23), that all organic structures originate in cells; and the same cells are equally indispensable in maintaining the structure when once formed. But cells *alone* cannot perform nutrition; but in addition to these, certain elements become necessary on which the cells may operate. The element, in its most primary form, is *albumen*. Cells become the *instruments*, albumen the *material* through which nutrition is accomplished. A due proportion between these elementary principles and agents, is necessary to secure the proper results. We next inquire more closely into the history of these changes.

39. Two classes of alimentary substances are necessary for the support of the animal system; the first embraces the protein compounds, containing nitrogen; and the second includes carbonaceous substances generally. The first is designed to support the tissues of the organs, while the second contributes to the maintainance of animal heat. But our object is to remark in this connection, that, however diversified the alimentary substances may be, all of the protein compounds are ultimately reduced, by the solvent action of the digestive fluid, to the state of albumen, or an albuminate of soda, so that they possess nearly a homogeneous character.

40. The albuminous compound thus formed, passes from the stomach to the duodenum, and there yields its chyle, which is absorbed by the lacteals. The chyle found in the intestinal walls, immediately after absorption, exhibits the beginning of that important series of changes, which are to result in nutrition. But it is still albumen; with the addition, however, of certain minute globules, which have been termed the *molecular base* of chyle. No important vital change, however, has yet taken place; the fluid does not coagulate spontane-

ously, which is evidence that *fibrin* is not present. Traced a little farther, and important changes become manifest. As the chyle approaches the mesenteric glands, two important changes take place; *chyle-corpuscles*, which are nucleated cells, for the first time make their appearance; and the fluid acquires the property of *spontaneous coagulation*, which is evidence that *fibrin* is present. Coincident with these changes, oil globules and albumen, constituents of the chyle, materially diminish.

41. The preceding changes constitute an important part of the elaboration of chyle. First, chyle when absorbed contains albumen, but no fibrin; in the next place, chyle-corpuscles and fibrin become developed; and at the same point, oil globules and albumen proportionally diminish. It would appear from these observations, that albumen had undergone further elaboration, being finally transformed into fibrin; and moreover, it is a legitimate inference, that the chyle-corpuscles are the agents through which this very peculiar and important change is accomplished. These chyle-corpuscles, therefore, which are true nucleated cells, may be regarded as possessing something of the properties of glands, and that through their agency albumen is transformed into fibrin. Immediately after the preceding changes have been effected, the chyle manifests a new property, which is that of spontaneous coagulation.

42. The chyle continues to undergo further changes as it advances; in the thoracic duct the coagulation is still more perfect, evincing a larger quantity, or more perfect development, of fibrin; and finally, after having entered the blood-vessels, it is submitted to the influence of oxygen, and thus the process of elaboration is completed. That the elaboration of albumen is important—indeed indispensable—is obvious from the fact, that albumen, *as such*, is incapable of organization; and if the change fail to take place, nutrition becomes impaired in proportion to the failure of this important function.

43. It is worthy of remark, that the chyle-corpuscles consist of several granules or nuclei united in a common cell; and that, after a given time, these cells burst or dissolve, and liberate their contents. The nuclei which are thus set free, each in their turn become cells; and thus these agents are propagated and their influence secured. And it should be carefully remembered in this connection, that if, from any cause, these cells fail to become duly developed, nutrition

will be proportionally impaired; for, as a necessary result, albumen will be imperfectly transformed into fibrin; and then the absence of cells and the predominance of albumen, greatly derange the nutritive actions.

44. It remains now to apply these principles to the pathology of Tubercle. We have already seen that in its chemical composition tubercle manifests the characteristics of albumen; that albumen is the great organic element in nutrition;—but that it is not itself organizable, but must undergo a transformation into fibrin before it can become a part of organic structures. When, therefore, the vital actions of the system have been impaired, as the result of accidental causes, but more especially of a hereditary tendency, and albumen predominates, with a dimunition of blood-copuscles; the elements of the tubercular diathesis exist, evinced by depressed vitality and impaired nutrition. Under these circumstances, a tendency is manifested to deposit albuminous materials in particular organs and structures; and as these deposites cannot become organized, they remain as foreign substances; or, in many instances, break down into molecular masses, and form tuberculous cavities. Extensive, and generally fatal ulcerated action supervenes; and this morbid process does not, in a general sense, tend to heal, because the deposits are not sufficiently vital to undergo organization. Hence the mischief extends, and finally terminates in fatal organic lesions.

45. The manner in which the tubercular deposit takes place is sufficiently obvious. The blood has become greatly vitiated as already described, but it is still the element from which the nutritive materials must be drawn; and, therefore, as the blood has suffered a degenerating change, nutrition is imperfectly performed. This change is first manifested in the chyle; the transformation of albumen is imperfectly performed; the cells which are themselves imperfect, fail to elaborate the nutritive elements to their physiological extent; and the plastic material takes on a low degree of vitality. From blood thus depraved, deposits are made in certain tissues; but instead of this consisting of nucleated cells and fibrin, which would be susceptible of complete and perfect assimilation to the tissues of the part; the material consists of albumen and granules, which are wholly incapable of becoming organized.

46. The *growth* of tubercle is readily explained. In a physiological condition, tissues *attract* elements similar to

their own, so that the particular variety of structure is kept up. And so of tubercle; when the vital actions become so deranged as to secrete tubercle, and that substance is deposited, similar particles or elements will be continually attracted to the same point, and thus its growth, by external additions, becomes a regular and specific action.

47. It is abundantly obvious that the blood is the immediate source from which tubercle is derived. It cannot be the result of *local* disease alone; for, long prior to the development of any local lesion, certain evidences of constitutional derangement are manifest; and these are often hereditary, and always general in their early manifestations. And, moreover, these deposits often take place without any organic change in the part other than the deposit itself; and it would therefore appear evident, that tubercle is a secretion, depending on a change in the blood from which it is derived, and not from any alteration or original disease of the structures in which the deposit accumulates.

48. It can scarcely be presumed, and certainly not demonstrated in our present state of knowledge, that the changes to which we have referred, belong exclusively to the blood. The grand defect consists in an imperfect development of cells and a consequent arrest of nutritive elaboration; and it must not be lost sight of, that this development of cells, and those progressive nutritive changes, obviously take place most rapidly and extensively in connection with certain solids—for example, the mesenteric glands. This fact suggests the idea, that important but obscure changes take place in the solid structures, and which lead to the imperfect cell development; and in this sense, the changes of the fluids would be arranged as secondary in the morbid actions. However this may be, that condition which we denominate the tubercular diathesis, is clearly an imperfect performance of the great function of assimilation; and in consequence of these changes, the elements of nutrition are imperfectly developed and transformed, and morbid products tending to disorganization, are deposited in different organs, but more especially in the Lungs. And so far as this great function of assimilation is under the influence of the solids,—of vessels nerves and cells,—so far is the mal-assimilation which constitutes the tubercular diathesis dependent upon the solids; and so far as these changes are effected in and by the fluids,—by the development of cells and the elaboration of fibrin,—so far is the change one belonging to the fluids. But it seems, upon the whole, sufficient-

ly obvious, that the solids are more or less at fault, having lost some of their appropriate vitality; and that the fluids have lost some of their power of elaboration;—from all of which the inference is deduced, that tubercular cachexy is brought about by certain depraved conditions of the solids and fluids, which are manifested by a general depression of the vital actions, and by imperfect assimilation in the fluids.

49. The preceding explanations of the tubercular diathesis, fully accord with the general observations, that all debilitating agents have a tendency to induce or develop tubercle. And hence, impure air, innutritious food, long continued and debilitating diseases, no less than a hereditary predisposition, all tend to induce the tubercular diathesis; or, if it already exist, to force it into full development.

6. *Changes which Tubercles undergo after having been deposited in the Lungs.*

50. Tubercle when once deposited in the tissues, appears susceptible of three different changes, which it becomes interesting to trace:—1. Contraction of its substance; 2. Softening; 3. Calcareous degeneration. The last change might with propriety be arranged under the head of softening, for that condition always precedes the calcareous deposit; but as the final changes are widely different, they may be separately described.

51. 1. *The Contraction of Tubercle.*—It appears that tubercle, at times, does not tend immediately to disintegration; but instead of liquifying, it undergoes a degree of condensation, in which condition it may remain for an indefinite period. This peculiar change is connected with that variety of tubercle which maintains some degree of vitality, which is especially evident in the gray species (§19); but this vitality is no more than sufficient to resist decomposition, and is incapable of passing into organization. The contraction is brought about by the granules, and may be thus explained. The low degree of vitality which these granules possess, enables the mass to resist decomposition, and by cell-absorption to secure a limited amount of nutrition; but instead of being further developed, or growing, their nutritive actions finally become so imperfect that they *retrograde*, diminish in size, the whole mass becomes more dense, and thus is formed the state of *Contraction.*

52. 2. *Softening of Tubercle.*—A good deal of speculation

has been indulged, at different periods, in regard to the mode and causes of tubercular softening. Some have affirmed that it took place *internally*, and that it evinced some sort of chemical or vital change in the tubercle itself; while others maintained, that the change resulted from surrounding inflammatory action, the purulent products of which dissolved the tubercle;—the softening, therefore, began externally. By comprehending the laws which govern the development of tubercle, but little difficulty will be experienced in forming correct opinions upon this subject. Both classes of observers are, in part, correct; but neither one exclusively so. It is unquestionable that tubercle may soften both *internally* and *externally;* and we submit the following explanation.

53. *a. Internal softening.*—It has already been shown, that tubercle possesses a low degree of vitality, by which decomposition is resisted for a limited period. But this vitality is imperfect, and the constant *tendency* is to decomposition; and when its imperfect cell-life is lost, the mass softens; and when the liquefaction depends on the cell itself, the change usually begins at the centre. This peculiarity accords with a well known law of organic actions, which is, that cells posses more vitality, more organic force, when in contact with healthy, solid structures, than under other circumstances; and, consequently, those farthest removed from such positions and influence, the most speedily die. This is precisely what occurs in the internal softening of tubercles; those portions which are exterior and in contact with solid structures, are sustained by the solid tissues; but the *central granules*, being farthest removed from the healthy structures, more readily lose their vitality, and consequently soften earlier than the external parts. The same principles will explain why the smaller tubercular masses can longer maintain the solid form. They are more under the influence of the solids, because each individual granule maintains a proximity to those solids; and thus even their central portions are not entirely removed from such control.

54. *b. External softening.*—The external softening of tubercle depends mainly upon surroundieg inflammation. Although free from inflammatory action when first deposited, tubercle has a decided tendency to irritate the surrounding tissues, and to develop inflammation. Now when this condition has been induced, tubercle tends to softening, because its connection with the surrounding tissues has been interrupted by the inflammation; but it is more immediately softened by the

solvent action of the pus produced by inflammation. Tubercle, therefore, softens by two modes: 1. By a change in the tubercle itself, which takes place internally, by liquefaction of the granules; 2. As the result of surrounding inflammation and the secretion of pus, which begins the softening externally.

55. 3. *Earthy or Calcareous Degeneration.*—This is a change connected with softening. It occasionally happens that the calcareous matter is secreted in excess; but the more common result is, that the softened animal matter is removed, while the earthy material remains. It has sometimes been observed, that the cavity becomes filled with this description of material, and the morbid action then ceases.

56. In regard to the *curability* of Phthisis, it may be stated, that all enlightened pathologists now agree, that a spontaneous cure not infrequently occurs. Post-mortem inspections constantly show that tuberculous cavities heal; this result is effected by a cessation of the tubercular deposit, and by a semi-catilaginous material being thrown out, which lines or obliterates the cavity. These instances of cure are usually mentioned as being spontaneous; and if the unaided efforts of nature are sufficient to accomplish such a result, we may reasonably infer, that well directed therapeutical efforts, will be still more frequently successful.

7. *Treatment of Phthisis.*

57. In the followlng observations on the subject of the Treatment of Phthisis, the object will be to point out, very briefly, the *general* therapeutics of the disease, leaving the reader to supply the details.—Keeping in view the preceding principles, the treatment naturally divides itself into two heads. 1. General treatment; 2. Local treatment.

58. 1. *General Treatment of Phthisis.*—If the disease depend, as has been stated, on a general derangement of the function of assimilation,—a derangement by which a morbid element is generated and subsequently deposited as a local disease,—it requires no argument to prove, that remedies must be addressed to the general system. It will obviously be vain to restrict our therapeutical agents to the lungs, while every link in the function of assimilation constitutes a part of the diseased action. The only philosophical course is to address remedies to the general system; and the tendency of these should be to restore the depressed vitality of

the system generally, but more especially the organs of assimilation. With this view, those agents which will restore and maintain secretion; that furnish healthy nutriment; and those that maintain the action and tone of the nervous and muscular systems, constitute the *classes* of remedies upon which reliance should be placed.

59. The necessity of maintaining the secretions in a healthy condition cannot be questioned. When the tubercular diathesis prevails, the blood loses much of its physiological action, which is evinced by a diminution of the blood-corpuscles; and as a necessary result of this change, the functions of the nervous system, and the secretions, become seriously impaired. Two primary objects, therefore, should be kept in view, which are, to restore the secretions, and to give tone to the system generally. The fulfilment of the first object should be attempted by those remedies which invigorate capillary action, and which thereby restore nervous energy. and increase the action of the principle secernent organs. This last indication is especially important, and without accomplishing it but little benefit will result.

60. For the purpose of meeting the indications mentioned in the preceding paragraph, no *class* of agents offers an equal prospect with that of *emetics*. It must not be supposed that this class of agents will permanently debilitate the system and thereby promote the morbid action; on the contrary, these remedies, when skilfully employed, will rather invigorate by removing causes of obstruction. The effect of an ipecacuanha emetic will be first, and during the nauseating impressions, to depress the nervous, vascular, and muscular functions; but speedily following this state of temporary depression, a healthy *reaction* takes place; the blood is thrown with renewed vigor to the extreme capillaries, and the nervous energy is thereby aroused; and the great secreting organs,—the liver, mucous membrane, skin, kidneys,—pour out in various proportions their appropriate secretions. And finally, in the place of depression, reaction ensues; the skin becomes moist with perspiration, the pulse expands, all of the secretions are augmented and more nearly approach a healthy state. Such is the reactive energy, indeed, under those circumstances, that all depression arising from the first influence of the medicine is removed, the vital actions are rescued from a state of depression, and assume a more healthy resiliency. It is obvious, therefore, that emetics, under proper restrictions, tend to improve secretion and innervation; and as they

promote new and healthy actions, they should be recognized as *alteratives*, so far as we can attach any definite meaning to that term. And it is equally clear, that the immediate tendency of such agents will be to break up the morbid diathesis, and to restore healthy assimilation.

61. But whilst emetics are thus being administered, another important indication is presented, which is, the employment of what are termed *Tonics*. It is true that, according to the views just expressed in relation to the effects of emetics, *they* may be termed *tonics*, for their ultimate effect is to restore tone and impart strength; but in addition to these *indirect* tonics, there is a very prominent indication for the employment of the remedies more appropriately belonging to this class. The indication for the employment of tonics is derived, in no small degree, from the condition of the blood. The researches of Andral, and others, have very satisfactorily proven, that in Phthisis the blood-corpuscles have suffered a remarkable diminution; and whether this decrease of corpuscles be regarded as primary or secondary, is quite immaterial, for it is equally injurious in either relation, and equally demands a remedy. Universal observation has clearly established, that in every instances where the blood-corpuscles become materially diminished, that the organic functions are proportionally impaired; and it is constantly observed that innervation, secretion, digestion, circulation, all suffer to a very large extent. This condition urgently demands a remedy; and experience amply testifies that we can usually do much for its removal.

62. The well known influence of the preparations of *Iron* in developing blood-corpuscles, at once suggests a remedy for the defects under consideration. For the purpose of securing the full influence of this class of remedies, and at the same time avoiding evil results, they should be administered simultaneously with emetics. If given anterior to the emetics, they are likely to be attended with unfavorable effects, and may fail to accomplish the end in view; but if so employed as to secure the agency of these two classes of remedies at the same time, the result will be vastly more favorable than when either one is employed singly. It is well known that under the administration of Iron, blood-corpuscles are rapidly multiplied; the effects of this physiological change, as shown in the restoration of the organic function, are too unequivocal to admit of doubt. And with a restoration of these functions, the entire process of assimilation is equally im-

proved; so that the condition upon which tubercle depends, will be removed in a degree corresponding with the therapeutical influences pointed out.

63. Another remedy deserves notice in this connection; I refer to *Iodine.* This agent has acquired a vast reputation, especially since the observations of Lugol have been made public; and there is no reason to doubt its beneficial influence when properly employed. The effects of Iodine on the system appear to be the following: It invigorates digestion, promotes capillary circulation, restores secretions, and imparts tone to the general system. It is not of paramount importance to determine, whether these effects result from a *direct* tonic influence, or whether they may not be a secondary result growing out of improved assimilation; for, although the latter appears to be the most probable, yet the former *may* be true; and at all events, the result is to remove that peculiar state of depression which we recognize as the tubercular diathesis.

64. In conducting the treatment of Phthisis, or of the Tubercular diathesis, our remedial agents should not be restricted to the mere administration of medicines; but in addition to these, certain hygienic measures are of the highest importance. And among these measure, the appropriate regulation of Diet is indispensable. It requires no argument to show, that so long as impure and innutritious food is received into the system, the nutritive demands of the functions will be imperfectly supplied; for it is hopeless to expect pure and healthy nutritive elements, either in quantity or quality, from scanty or impure food. To meet this indication, bland but nutritious food should be given; but even the lightest article of diet should never be in such quantities as to oppress the digestive function. Great discrimination is here important. When too much food is administered, the digestive organs, and indeed the whole assimilative system, become impaired, and the food is imperfectly digested; and if imperfectly digested, it not only proves a source of irritation, but an undue quantity of crude and effete material gains admission to the circulation, which will seriously obstruct the vital actions. It must be borne in mind that, in the tubercular diathesis, the functions of the excreting organs are impaired; and therefore, if an undue quantity of effete material accumulates in the system, it cannot be removed with the necessary facility, and its retention becomes an evil of no ordinary magnitude. It is perfectly clear, that the pernicious habit of *over-feeding*, very

greatly aggravates the tubercular diathesis; for if the nutritive elements be forced into the system in larger quantities than can be completely digested or fully assimilated, the appropriate transformations will not take place, and imperfectly elaborated albumen will predominate. With the view, therefore, of securing the most favorable results from diet, the aliment should consist of an appropriate quantity of nutritious and easily digestible substances, in such quantities that their digestion may be perfect;—all of which must be regulated by an enlightened view of the functions of digestion and assimilation.

65. As further hygienic measures, pure air and healthy exercise are indispensable; indeed, so imperious is the demand for pure air, that all other remedies will usually fail in its absence; and appropriate exercise is scarcely less necessary than either of the preceeding. These rules, however, are too obvious to require comment.

66. 2. *Local Treatment of Phthisis.*—The local treatment must always be held in subordination to the general remedies; but it is frequently of great importance in mitigating secondary disease. When tubercle has been deposited in the lungs, it manifests a very constant tendency to excite irritation and inflammation in the adjacent tissues; and it cannot be doubted, that when such a lesion supervenes, counter-irritants and local bleeding are highly servicable in subduing the local affection. But these measures are no more than palliatives, and cannot, under any circumstances, supersede the general remedies.

67. In the preceding hasty *sketch* of the Treatment of Phthisis, nothing more has been designed than to present an *outline* of the subject; and many agents belonging to the several *classes* of remedial measures mentioned, which have not been referred to, may be beneficially employed; but as the object was to treat the subject in a general way, more detail was not practicable. The course which has been indicated, may be termed *preventive* rather than *curative*; still if it should arrest the tubercular diathesis, it may be said to have cured the disease. In relation to the prospect of *success*, different opinions prevail; there is a growing belief, however, based upon enlightened pathology and therapeutics, that the disease in its earlier stages is not so hopeless as many suppose; and, to say the least, the instructive lessons derived from pathological anatomy, that nature frequently accomplishes a cure, is a sufficient incentive to renewed exertions.

68. Finally, we reach the following conclusions:

1. The chemical composition and minute of structure of Tubercle clearly prove that it is inorganic.

2. Although inorganic, tubercle possesses a low degree of vitality, which depends upon an imperfect cell-life remaining in the granules

3. The history of Tubercle, its composition, the appearances of the tissues in which it is deposited, its location, and other considerations, prove that it is not of inflammatory origin.

4. That several products of chronic pneumonitis, (including the granulations of Bayle,) bear a striking resemblance to tubercle, but are widely different in character and causes.

5. That tubercle owes its origin to an impaired condition of the solids and fluids—hereditary or accidental—the most evident condition being depraved assimilation, in which the albuminous element is imperfectly elaborated.

6. Tubercle undergoes three changes—contraction, softening, and calcareous degeneration. Softening may begin in the centre, or on the surface; when central, it depends upon a vital change in the tubercle itself; when external, it is more generally the result of inflammation, and the solvent action of pus. Calcareous transformation is a modification of softening.

7. In the treatment, the object should be to impart tone to the system, restore the secretions, and to establish healthy assimilation. The most appropriate remedies to accomplish these objects, are, Emetics, Iron, Iodine, etc., and certain hygienic measures.

A CONDENSED TABULAR VIEW

OF THE

PHYSICAL SIGNS AND PATHOLOGICAL ANATOMY

OF

THORACIC DISEASES.

BY L. M. LAWSON, M. D., ETC.

PHYSIOLOGICAL CONDITIONS OF THE LUNGS.

Anatomical Characters.—The *tissue* of the lungs consists of air-cells, ramifications of the pulmonary artery and veins, bronchial arteries and veins, nerves, lymphatics and areolar tissue. The air-cells, or vesicular terminations of the capillary bronchi, are sacs, composed of mucous membrane, a fibrous structure of an elastic character, and probably a few muscular fibres. The *pulmonary artery* terminates in capillary vessels on the walls of the air-cells, and gives rise to the pulmonary veins. The *pulmonary artery* conveys venous blood to the air-cells for the purpose of being arterialized; the *bronchial arteries* are the nutrient vessels of the lungs. The *parenchyma*, that portion of the lungs which is the seat of pneumonitis, consists of all the intervening structures between the air-cells and the pleura.

Percussion.—Sound clear over the chest generally; most distinctly marked under the clavicles; dullness in the regions of the heart and liver.

Auscultation.—Respiratory or vesicular murmur heard over the chest; it may be designated a soft breezy sound, produced by air coming in contact with the air-cells. Two sounds may be heard, one corresponding to *inspiration*, and the other to *expiration;* the former much the most intense and prolonged. This murmur is most distinct in the superior anterior, and lateral regions. Natural bronchial respiration and bronchophony heard in spaces corresponding to the root of the lungs. Natural voice and cough produce a slightly vibratory sensation, or *fremitus.*

General Observations.—The intensity of the respiratory murmur varies with age and constitutional peculiarities; during infancy it is loud, and hence the *puerile* respiration; in old age it becomes comparatively feeble, and inspiration is diminished in du-

ration; and in some adults in a healthy state, it is much more distinct than in others. The sounds resulting both from percussion and respiration, are most audible in the axilliary and clavicular regions; less distinct in the mammary and infra-mammary regions; and comparative dullness will be observed over the heart and liver. Posteriorly, the sounds are feeble and dull over the scapulæ, more loud and clear in the inter and infra-scapular regions.

BRONCHITIS.

Anatomical Characters.—In the *Mucous Membrane:* Redness; thickening—1st, from congestion; 2d, from hypertrophy; softening and ulceration. *Bronchial tubes:* Dilatation, atrophy. *Cellular tissue:* Œdema, hypertrophy, induration.

Percussion.—Sound elicited by percussion usually clear; when, however, there are large collections of mucous, or when the disease extends to the areolar tissue, and causes congestion, some degree of dullness may be detected, which occurs at the inferior and posterior regions.

Auscultation.—Respiratory murmur more or less obscured, or temporarily suppressed; sibilant, sonorous, mucous, and muco-crepitating rhonchi.

General Observations.—Bronchitis may be either primary or secondary, general or local; the intensity of the râle is usually proportioned to the severity of the disease. The respiratory murmur may be suppressed by mucous obstructing the tubes. Hypertrophy, ulceration, dilatation, induration, belong to the *chronic* forms. The *sibilant râle* results from narrowing of the tubes; *sonorous* and *mucous* from air passing through a fluid—the mucous.

PNEUMONITIS.

Anatomical Characters.—Pneumonitis consists of three saparate stages. 1st. *Engorgement* of the vessels of the air-cells, minute bronchial tubes, and cellular tissue; more or less exudation takes place during this stage. 2d. *Hepatization*, which consists of complete obliteration of the air-cells, resulting from tumefaction of the parts, but more especially the effusion of lymph. 3d. *Suppuration*, in the form of *purulent infiltration*, more rarely of *abscess*.

Percussion.—1. *Stage of engorgement:* Clearness of sound diminished in proportion to the engorgement. 2. *Stage of hepatization:* Sound becomes less clear until complete dullness is manifested. 3. *Stage of suppuration*, (grey hepatization): dullness similar to the *second;* mucous rhonchus frequently heard.

Auscultation.—1. *Stage of engorgement:* Weak respiratory murmur; crepitant rhonchi; some bronchial cough. 2. *Stage of hepatization:* Cessation of respiratory murmur; bronchophony; sounds of the heart freely transmitted to the right side.

General Observations.—The structures *necessarily* involved in pneumonitis are those between the mucous and serous tissues; and these, also, are very commonly implicated, especially the mucous. The lymph is effused into the areolar tissue and the air-cells, the latter being most speedily destructive. The *crepitating rhonchus* is caused by air bursting through the fluids effused into the air-cells and capillary bronchi. *Bronchial respiration* results from air acting on the larger bronchial tubes. The *rusty colored* expectoration ("characteristic") is sometimes absent. In some instances, [typhoid,] the stages follow each other so rapidly, that the characteristic *crepitating rhonchus* does not occur. Resolution may take place, and the disease recede, as it had advanced, through its different stages. Pneumonitis is most frequent in the right lung; it may involve the entire lung, or be confined to individual lobuli.

PLEURITIS.

Anatomical Characters.—The pathological changes in pleuritis, relate to the membrane and the secretions. In an early stage, the only changes consist in increased vascularity, first of the subserous cellular tissue, and next of the membrane itself. *Plastic lymph* is thrown out on the inflamed surface, and forms a *false membrane*, often of considerable thickness, which becomes organized. Serum, more or less pure, is also speedily effused, frequently in large quantities. *Sero-purulent fluid, true pus* and *bloody serum*, are also the products of pleuritis.

Percussion.—In the first stage, before any sort of effusion occurs, the sound is clear; after the exudation of lymph, some dullness supervenes. When *serous effusion* has taken place, dullness will be manifested in proportion to the quantity of fluid; and when it gravitates, dullness will be most manifest at the postero-inferior part. and extending upwards.

Auscultation.—Respiration accelerated; inspiration short. Before effusion, merely week respiration, with occasionally slight friction sound. During the *stage of plastic exudation*, weak respiration with decided *friction sound. Stage of serous effusion;* suppressed or weak respiratory murmur; cessation of friction sound; ægophony, when little fluid; bronchophony, when the fluid is abundant; occasional bronchial respiration; absence of vocal vibration.

General Observations.—The first decided morbid sound is that of the *friction* or rubbing sound, produced by unorganized lymph on the opposing pleural surfaces; it is frequently heard in an early stage, and then disappears, in consequence of the effused serum separating the surfaces of the membrane. The serous effusion exists in what is termed the *laminar* form, that is, the fluid extends evenly over the pulmonary surface; and also in the *gravitating* form, when it sinks to the lower part of the chest.

Bronchophony results from the compressed lung and fluid transmitting the vocal sound; and *Ægophony*, which is only a modification of *bronchophony*, and is heard when the effusion is small, is probably caused by the voice producing a vibration in the fluid. When the fluid gravitates, the superior part of the chest becomes comparatively clear. In consequence of the presence of the liver, dullness is less distinctive on the right side. The heart is frequently greatly displaced.

EMPHYSEMA.

Anatomical Characters.—Emphysema exists under two varieties—*vesicular* and *interlobular*. The *vesicular* variety is formed by the dilatation of the air-vesicles; the interlobular is the result of infiltration of air into the cellular tissue, by the rupture of air-cells or otherwise. It is sometimes connected with atrophy of the cells,—as in old persons,—occasionally with hypertrophy.

Percussion.---Sound upon percussion preternaturally clear, or tympanitic.

Auscultation.----Respiratory murmur weak; expiration prolonged; complicated with sibilant or mucous rhonchi when bronchitis exists.

General Observations.---Emphysema is very frequently the result of bronchitis. which is manifested by its usual signs; it may exist, however, independently of that disease. Diminution of the respiratory murmur depends on the loss of elasticity of the air-cells. The *friction* sound sometimes heard, arises from rubbing of the opposing pleural surfaces. The chest frequently becomes expanded by the enlarged air-cells. Constant dyspnœa, bluish tinge of the lips, cough with slight expectoration, are some of the most common symptoms.

PNEUMOTHORAX.

Anatomical Characters.—Pneumothorax signifies an accumulation of air or gas in the cavity of the pleura. It may be apparently spontaneous, but is more commonly the result of pleuritis, pneumonitis, gangrene, or tubercles. The disease frequently arises from ulceration, as in tubercular softening, forming a communication between a bronchial tube and the cavity of the pleura.

Percussion.---Sound preternaturally clear; tympanitic; dullness at the lower portion when accompanied with serous effusion.

Auscultation.---Weak or suppressed respiratory murmur: vocal resonance weak or suppressed; metallic tinkling; [tintement métallique,] amphoric voice.

General Observations.---The urgent symptoms in pneumothorax, proceed from *compression* of the lung, resulting from the

accumulation of air or gas within the pleural cavity. If the accumulation be very great, the lung will be unable to expand; and should it occur in both cavities at the same time, *asphyxia* must necessarily be the result. Serous effusion is sometimes connected with aeriform accumulation; when this occurs, the inferior part of the chest will manifest dullness, while the portion above is clear. *Succussion* will aid in detecting the presence of liquid.

PULMONARY APOPLEXY OR HÆMORRHAGE.

Anatomical Characters.—Pulmonary hæmorrhage may be the result of *effusion*, or transudation of blood through the capillary walls; or, when the pressure is very great, a rupture may take place. Nature makes an effort, by absorptinn, to remove the effused blood.

Percussion.—Dullness of sound proportioned to the amount of effused blood; when the hæmorrhage is small, the dullness will not be appreciable.

Auscultation.—Respiratory murmur weak; puerile respiration in the unaffected part; bronchial respiration; sub-crepitant with mucous rhonchi.

General Observations.---When the effusion extends to the bronchial tubes, *hæmoptysis* occurs; but when the blood accumulates in the substance of the lungs, it may exist without expectoration. Organic disease of the heart, particularly of the mitral valve, conjoined with hypertrophy of the left ventricle, is the most common cause of the disease. The lower lobes are its most common location.

PHTHISIS.

Anatomical Characters.---Tubercle is a non-vascular substance, deposited on the air-cells, and, perhaps, also, in the cellular tissue of the lungs. It is of an albuminous character, and seems to be deposited as a result of deranged nutrition and secretion. Tubercular matter undergoes two varieties of transformation. 1st. By *softening*. 2d. The *cretaceous* or *earthy* transformation, in which the animal matter is absorbed, and the earthy deposited. If a bronchial tube be opened by ulceration, expectoration of tubercular matter, of either variety, may occur. When softening takes place, the surrounding tissues generally become ulcerated.

Percussion.---Dullness, especially in the infra-clavicular, and supra-scapular regions; clearness of sound diminishes as the tubercular deposition increases, until complete dullness is manifested. Large excavations will give rise to clearness of sound.

Auscultation.----Respiratory murmur weak, suppressed, or masked by other sounds; puerile in the unaffected parts. Expi-

ration prolonged and intense; slight, dry, crackling sound; occasionally mucous rhonchi; more or less bronchial respiration and cough, and bronchophony; vibration of the voice increased. When softening occurs, cavernous rhonchi, respiration and cough, one or all; pectoriloquy; metallic tinkling.

General Observations.----The dull sound, and the weak respiratory murmur, are produced by the tubercular deposit displacing air; mucous rhonchi depend on the presence of bronchitis; the crepitating rhonchi on inflammation; cavernous rhonchi are produced by air entering a cavity containing fluid; cavernous respiration occcurs when air enters a cavity partially or entirely empty. Bronchophony, bronchial cough and respiration, depend on consolidated lung. Pectoriloquy is heard when the cavity is large, and is situated near the surface.

Tubercle is not necessarily connected with inflammation; that condition, however, often occurs as a consequence of the excitement caused by by the extraneous substance; and hence, hepatization and adherent pleura, are common events. It is most commonly deposited at the apex of the left lung.

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DISEASES OF THE HEART.

PHYSIOLOGICAL CONDITIONS OF THE HEART.

Anatomical Characters.---The substance of the heart is muscular; it consists chiefly of the *non-striated* or involuntary muscular fibres, but contains also some of the *striated* fibres. These fibres are composed of flattened bands or tubes, with a few nucleated cells; and, in this organ, they also present some transverse striæ, resembling the voluntary muscles. Three orders of fibres have been observed, viz: *superficial*, *middle* and *internal* layers. All of these interlace in various directions, and are arranged spirally, so that their contractions lessen the cavities equally in every direction. The *pericardium* consits of two layers---an *external fibrous*, and an internal *serous* coat, constituting it a *fibro-serous* membrane.

Percussion.---Percussion elicits a dull sound over the heart, extending from the fourth rib to the point of pulsation, between the fifth and sixth ribs, embraciug a diameter of from one and a half to two inches.

Auscultation.---The heart pulsates between the fifth and sixth ribs, from one to two inches to the left of the sternum. Two sounds, called the first and second sounds, during a pulsation of the heart: 1. *A dull prolonged sound*, caused by the combined ac-

tion of the auriculo-ventricular valves, and the muscular sound produced by contraction of the ventricles. This sound corresponds with ventricular contraction and the *impulse* of the heart, and is most distinctly heard over the dull space. 2. *A sharp quick sound*, caused by the column of blood rushing back, during ventricular diastole, and closing the sigmoid valves. It is heard most distinctly at the base of the third rib, a little to the left of the sternum.

General Observations.---A line drawn along the left margin of the sternum, would leave *one-third* of the heart, consisting of the upper portion of the right ventricle. and the right auricle, on the right; *two-thirds*, consisting of the lower part of the right ventricle and all of the left ventricle and auricle, on the left. In the movements of the heart, the following order is observed: 1. Systole of the auricles; 2. Systole of the ventricles; 3. Diastole of the ventricles; 4. Interval of repose. A pulsation of the heart may be estimated at *one second:* and of this period, Laennec supposed the ventricular contraction to occupy one-half, dilatation one-fourth, and the remaining fourth to be a period of repose; so that the ventricles rest 12 out of the 24 hours. Medium weight of the heart, 8 to 9 ounces; thickness of the left ventricle, 6 to 7 lines; right ventricle, $2\frac{1}{2}$ lines; left auricle, $1\frac{1}{2}$ lines, and right auricle, 1 line. These estimates are sufficiently accurate for all practical purposes.

PERICARDITIS.

Anatomical Characters.---The anatomical changes consist of redness, effusions of lymph, serum, pus, or blood. The pericardium is rarely thickened; and whatever increase may seem to take place, is due to the presence of false membrane, the thickness of which does not usually exceed one or two lines, but may be increased to an inch. Adhesicns more or less perfect take place in some cases; the lymph while soft and ductile may be drawn into eminences, leaving corresponding depressions. General adhesion is not a very fortunate result, for it causes great obstruction and even hypertrophy.

Percussion.---Dullness over the region of the heart, proportioned to the amount of effusion.

Auscultation.---Impulse at first increased; after serous effusion takes place, the impulse is less obvious. *Friction sound* is usually heard, accompanying both sounds, but disappears when serous effusion takes place, or when general adhesion occurs. General adhesion is indicated by absence of fever, and friction sound and dullness, with increased impulse, and irregular action. If endocarditis exists, valvular murmur will be heard.

General Observations.---Pericarditis may be produced by any of the ordinary causes that excite inflammation; but it it is more

frequently associated with *rheumatism* than any other condition of the system. The pericardium is a fibro-serous membrane, and hence its structure renders it liable to rheumatic inflammation. It is not strictly true, however, that a *metastasis* takes place in these cases; on the contrary, there is merely an *extension* of disease to the heart. Pericarditis is frequently associated with carditis and endo-carditis, and in some instances with pleuritis and pneumonitis. The pulse varies; sometimes it is hard and full; frequently small, irregular and intermittent, with a tendency to syncope.

CARDITIS.

Anatomical Characters.---Increased redness and vascularity; softening; abscess; ulceration. Induration is also regarded as a result of chronic carditis.

Percussion..---Slight dullness may result from engorgement of the heart.

Auscultation.---Palpitation, irregular action; impulse diminished if softening be present, otherwise it may be increased; sounds of the heart not materially altered.

General Observation.---Carditis so rarely exists without involving the membranes, that it becomes difficult to designate any characteristic signs. Softening is one of the most common results of carditis: but it may exist independently of inflammation. Abscess is rare, and is the result of partial inflammation. The pulse is usually feeble and irregular.

ENDOCARDITIS.

Anatomical Characters.---Increased redness and vascularity; thickening of the membrane; effusion of lymph and pus; ulceration. The valves are the most common seat of organic changes in endo-carditis. The blood frequently coagulates, and the fibrin adheres to the columnæ carneæ and chordæ tendineæ, and extending into the adjacent vessels. This is what has been called, improperly, *polypus*. It induces great obstruction.

Percussion.---Dullness; this is slight when but little obstruction exists, but when the circulation is impeded, either from over distension, or the formation of coagula, the dull space may extend from 3 to 6 or 7 inches in diameter.

Auscultation.---Impulse increased; when obstruction exists, it becomes tumultuous and irregular. Thickening, or contraction of the valves, will give rise to murmurs; these murmurs arise chiefly in the auriculo-ventricular valves, particularly the mitral, but may extend to those of the arteries. They most frequently coincide with the first sound, but may be connected also with the second; they are produced either by regurgitation, or obstruction, or both.

General Observations.---Endo-Carditis is a common result of rheumatism; it is also occasionally observed in pneumonitis, pleuritis, and inflammation of other serous tissues. It is rarely found alone, but usually coexists with pericarditis. Lymph and pus, when formed, are usually washed away; but lymph, in the form of vegetations, is often found adhering to the valves. Endo-Carditis is the chief cause of vlavular disease, and hence its great importance. Three signs may lead to its detection: 1st, Fever. 2d, Valvular murmur. 3d. Violent impulse. The pulse, before obstruction, full and strong; after obstruction, small, weak, irregular, intermittent.

VALVULAR DISEASES.

Anatomical Characters.---Valvular diseases, like all other affections of the heart, are vastly more common in the left than the right side. They are more frequently produced by rheumatic inflammation than any other cause. The changes consist in thickening; vegetations; ulcerations; induration; ossific and calcareous deposits. When disease affects the margin, they are prevented from duly closing, and *regurgitation* is the consequence. When the base of the valve is mostly implicated, contraction and *obstruction* exists; or the two may be combined. Hypertrophy or dilatation, or both, are often complicated with valvular disease. Hypertrophy is rather *conservative*, as it assists in overcoming an obstruction; but dilatation greatly augments the obstruction of the circulation.

Percussion.—When unaccompanied by hypertrophy or dilatation, percussion elicits a natural sound; when enlargement exists, proportional dullness will be manifested.

Auscultation.—When obstruction or regurgitation exists to any considerable extent, a murmur will be heard. This may accompany the first or second sound. Various sounds are heard, viz: The bellows sound, (*bruit du suffle;*) filing sound, (*bruit de lime;*) rasping sound, (*bruit de rape;*) sawing sound; [*bruit de scie;*] and other modifications are heard under different circumstances. The sound varies with the degree and character of the disease, and the force with which the blood is propelled.

General Observations.—Cardiac murmurs are heard most distinctly at the following points: *Mitral Valve: Regurgitant.*—At the apex of the heart, below and a little to the left of the mamma, and accompanies the *first sound*. *Obstructive.*—At the same point, but occurring with the second or diastolic sound. *Aortic Sigmoids: Obstruction.*—At the base of third rib, near the left margin of the sternum; it accompanies the *first* sound. *Regurgitant.*—At the same point; connected with the *second* sound. Murmurs of the pulmonic valves are most audible at the left margin of the sternum, where the artery bulges between the 2d

and 3d ribs. Obstructive murmurs of the auriculo-ventricular valves, are low and weak, as are also the regurgitant of the arteries. Murmurs connected with the tricuspid valve and the pulmonary artery are extremely rare. In disease of the mitral valve, the pulse is small, weak, irregular and intermittent; in regurgitation through the aortic sigmoids, a *jerking* pulse is felt, i. e. the artery is well filled, but the column of blood is not sustained, and it seems to slip under the finger.

HYPERTROPHY.

Anatomical Characters.—Hypertrophy is divided into three varieties: 1. *Simple hypertrophy*, in which the cavity preserves its natural capacity. 2. *Hypertrophy with dilatation.* 3. *Hypertrophy with contraction.* In hypertrophy, there is simply *increased nutrition.* without any essential change of structure; the texture, however, exhibits a slight increase of redness and vascularity. The thickness of the left ventricle varies in hypertrophy but rarely exceeds 12 or 18 lines: the right ventricle seldom reaches above 4 or 5 lines, but may extend to 10 or 12.

Percussion.—Dullness over the region of the heart, proportioned to the enlargement; occasonally reaching an extent of 6 or 7 inches, particularly when united with dilatation.

Auscultation.—Impulse increased; in simple hypertrophy, and when contraction of the cavity exists, both sounds are materially deadened. If dilatation be present, they are greatly increased. If produced by valvular disease, the characteristic murmur will be heard.

General Observation.—Hypertrophy is most frequently met with in the left ventricle; it is sometimes partial; rarely involves the whole organ. Obstruction such as results from valvular disease, is the most common cause of this affection. The great preponderance of valvular disease in the left side, is one cause of the frequency of hypertrophy of the left ventricle. It should rather be regarded as concervative, than a source of obstruction. The *pulse* in hypertrophy is *full and strong*, except when contraction exists, and then it becomes *small and tense.*

DILATATION.

Anatomical Characters.—These varieties of dilatation exist. 1. *Simple dilatation*, or enlarged cavity without thinning of the walls. 2. *Dilatation with hypertrophy.* 3. *Dilatation with attenuation.* The walls of the heart in this affection are usually flaccid or softened; sometimes, however, the structure remains healthy.

Percussion.—Dullness of sound considerably increased, in consequence of a large surface of the heart coming in contact with the thoracic parietes.

Auscultation.—Impulse diminished; *first sound* louder, clearer. and shorter than natural; *second sound* likewise increased in intensity.

General Observation.—The signs of dilatation will vary with its different species. When very great, the auriculo-ventricular valves may be insufficient to close their orifices, and regurgitation will take place, evinced by a murmur. The same general causes that induce hypertrophy in some cases, will, in other instances, when operating on a yielding fibre, give rise to dilatation. This condition is a source of great embarrassment to the circulation. The pulse is soft and feeble; fuller when hypertrophy is complicated with dilatation. When the right side is affected, distension of the external jugular veins is an important sign.